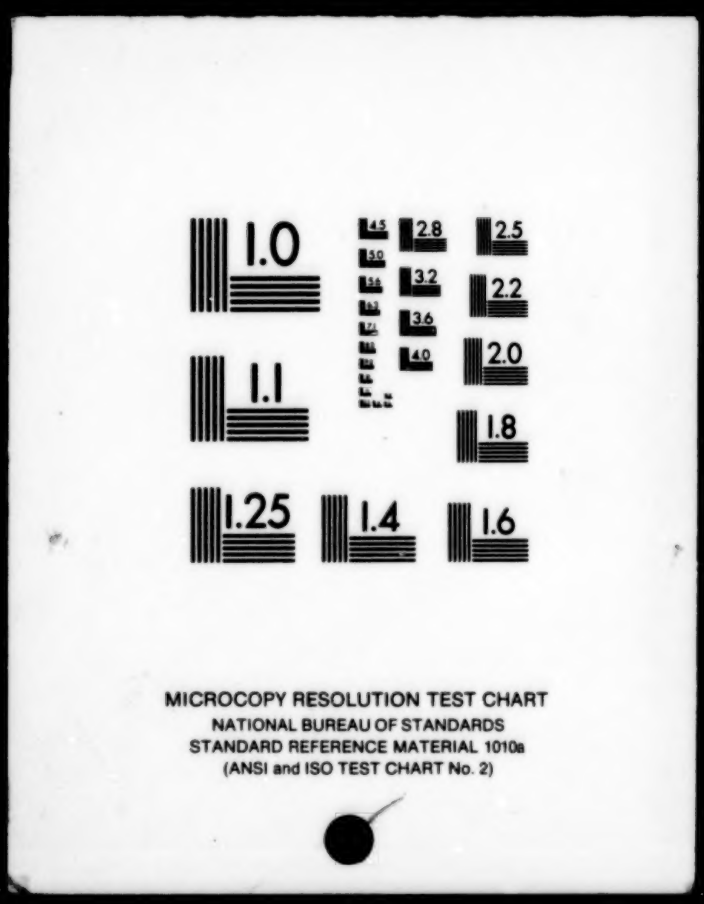


Physical Vapor Transport of Organic Solids Apparatus (PVTOS)

The 3M PVTOS hardware is used for growing crystalline solids and thin films by gaseous diffusion, and for studying vapor phase transport phenomena in microgravity. Nine individual cylindrical cells, each roughly 3 inches in diameter and 12 inches long, contain a vacuum insulated heater core surrounding a specialized reactor tube, a heat-pipe-cooled substrate within the reactor tube and thermocouples to monitor the temperature at various locations.

PVTOS is designed to operate nominally at 400° C. The cell design intrinsically provides double hermetic confinement of the source material, utilizing all metal-to-metal seals. Modifications are feasible to fit customized needs.

Operational Characteristics

Operating temperature:	400° C (higher temperatures possible)
Power:	50 W
Size:	2 middeck locker spaces
Weight:	56.7 kg with EAC

Carrier: The unit is housed within an Experimental Apparatus Container and can be mounted into the Shuttle middeck or cargo bay carriers, Spacelab or SPACEHAB facilities.

Available: Now

Contact: E. L. Cook
3M Space Research and Applications Laboratory, Bldg 201-2N-19
3M Center
St. Paul, MN 55144
(612) 733-4357

Individual Cylindrical Cell

Protein Crystal Growth Experiment Apparatus (PCG)

Protein crystals grown in the PCG apparatus, because of their potential size, degree of purity and quality, are highly valued for crystallographic analyses.

The PCG carrier assembly accommodates three trays, each of which can hold one or more Vapor Diffusion Apparatus (VDA) units. Each VDA holds 20 PCG experiments, which are activated simultaneously, and the crystals are returned to Earth for analysis.

Operational Characteristics

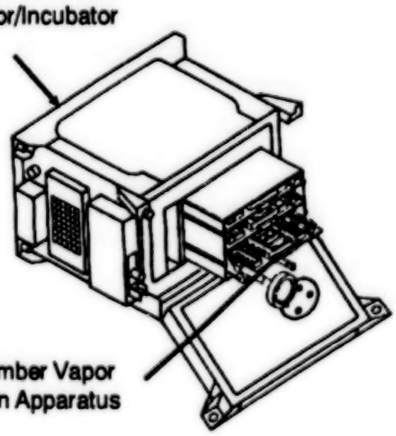
Sample capacity:	Up to 100/flight
Droplet size:	Up to 80 microliters
Precipitant reservoir:	1 ml
Apparatus size:	38.8 cm L x 25.7 cm W x 16.2 cm H
Apparatus weight:	13.7 kg
Temperature range (R/IM):	0 to 50° C

Carrier: Shuttle middeck, Refrigerator/Incubator Module

Available: Now

Contact: NASA/Marshall Space Flight Center
Microgravity Projects, Code JA81
Marshall Space Flight Center, AL 35812
(205) 544-1988

Refrigerator/Incubator Module



20-Chamber Vapor Diffusion Apparatus

C-2

Refrigerator/Incubator Module

This apparatus is an active unit with a temperature range from 0° to +40° C. The temperature is set using a front-mounted variable potentiometer. Switching between the refrigeration and incubation modes occurs automatically.

Operational Characteristics

Control temperature:	0° to 40° C (+/-0.5° C)
Ambient range:	2° to 50° C
Weight size:	19.35 kg
Internal size	
2 sections:	16.4 cm x 25.88 cm x 36.98 cm, 4.27 cm x 13.97 cm x 16.41 cm
External size:	27.89 cm x 49.15 cm x 48.9 cm

Carrier: Shuttle middeck locker or Spacelab

Available: Now

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736

Life Sciences

Animal Enclosure Module (AEM)

The AEM supports up to six 350-gram rats and fits inside a standard middeck locker. A removable divider plate provides two separate animal holding areas, if desired. The AEM may be removed in orbit for viewing or photographs. It also will fit within the General Purpose Work Station (see page 88). The current unit has a 1500 cc and 2000 cc capacity automatic watering unit.

Operational Characteristics

Size:	24.5 cm x 43.69 cm x 51.05 cm
Floor space:	125 in^2
Weight, loaded:	26.8 kg
Temperature:	Shuttle or Spacelab ambient

Carrier: Shuttle middeck or Spacelab

Available: Now

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736

Experiment Module TEM 06-16

This module has been used for investigation of flow pattern within algae roots and to research the influence to the g-sensors of the algae in the roots. The module is designed to carry 5 different experiment cells containing the algae roots. One cell is used to observe the flow pattern within the root under microgravity. The other 4 cells are used to observe the delocation of the g-sensors in the roots. Experiment evaluation takes place after the flight by special preparation and evaluation of the algae roots.

Operational Characteristics

Module length:	462 mm
Module weight:	34.0 kg

Carrier: Shuttle middeck

Available: Now

Contact: SpaceTech
58 Charles Town Road
Kearneysville, WV 25430
(304) 728-7288 or (703) 385-4355

Frog Environmental Unit (FEU)

The FEU is a gravitational biology/embryology experiment package containing a centrifuge, adult frog holding unit and an 0-g egg storage chamber.

The centrifuge rotates at approximately 60 rpm and yields 1-g, providing a control environment for embryos developing at 0-g. The adult frog chamber will accommodate four female frogs, is removable, and usable at the General Purpose Work Station (see following entry). The egg chambers are small acrylic structures (3.0 in x 3.0 in x 3.5 in) with valves for syringes accessible during experiment operations. Up to 56 chambers can be housed in the FEU.

Operational Characteristics

Size:	Fits lower portion of Spacelab rack, approx. 33 in H
Weight:	160 kg
Chambers:	56 – 28 on the centrifuge, 28 in trays in 0-g storage

Carrier: Spacelab

Available: Now

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736

General Purpose Work Station (GPWS)

The GPWS is a broad range support facility for general laboratory operations in the Spacelab. It can support animal experiments, biological sampling and microbiological experimentation.

The GPWS provides working space and accommodates the laboratory equipment and instruments required for many life sciences investigations. The unit is self-contained and has a rack-mounted, retractable cabinet with a large front door, allowing experimental hardware to be mounted in the cabinet.

Operational Characteristics

Size:	One double Spacelab rack, approx. 41.5 in W x 108 in H x 30 in D
Weight:	765 lbs

Carrier: Spacelab (double rack)

Available: Now

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736

Get-Away-Special Type Container for Middeck Locker Usage

The space qualified container is modular in concept and, except for an On-Off switch, requires no Shuttle interaction. The container consists of an experiment compartment and an instrumentation compartment. The current experiment compartment contains 18 experiment chambers. Each is readily accessible and is temperature and humidity controlled. The experiment compartment can be tailored to accommodate a variety of experiment requirements. The instrumentation compartment has provisions for two tape recorders and video recording. There also are audio and temperature sensing capabilities controlled by a programmable microprocessor.

Designed for PROJECT ISAIAH, an investigation of the effects of microgravity on the ability of a species of hornets to sense gravity, the apparatus has provision for creating day-night lighting, temperature and humidity control, food, audio pickups and optics for video recording. A filter system eliminates fumes or odors. In the event of launch delay, individual experiment chambers can be opened and the insects replaced in less than two hours.

The complete complement of equipment includes a similar container for the ground test which is conducted simultaneously with the flight test, an electrical test set for check-out purposes and shipping containers. A modular packaging approach offers the opportunity to tailor the system to other experiment requirements.

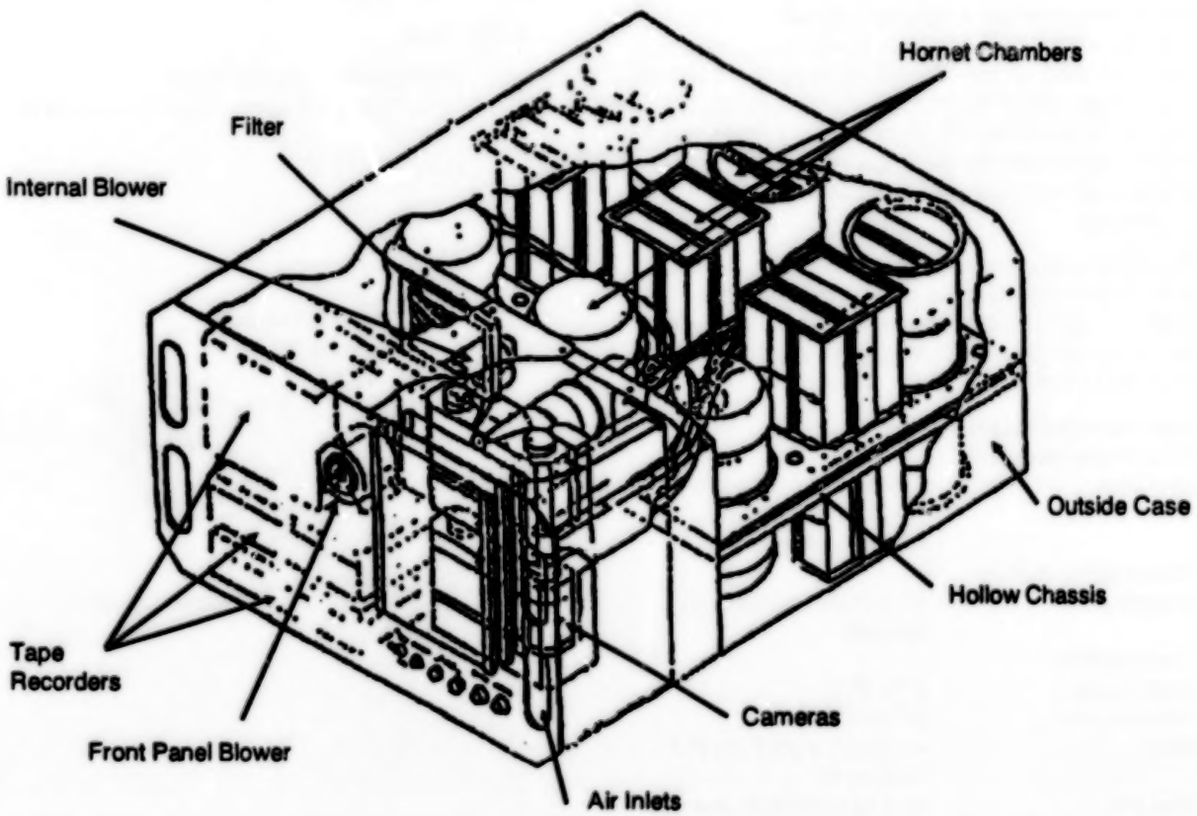
Operational Characteristics

Temperature control:	Independent closed loop
Two Analog Tape Recorders:	Provides 14 channels for 3 hours of sound recording
Data Recording:	Non Volatile Memory 32 Kbyte, expandable
Fail Safe Real Time Clock	
Electronics System:	24 digital output lines; 40 digital input lines
3 Digit Display Monitor	
Power Required:	28 Vdc, 43 W
Weight:	25 kg

Carrier: Shuttle middeck accommodation rack

Available: Now; modifications may be required for Free Flyer/Space Station

Contact: Robert Schecter
IAI INTERNATIONAL INC.
1700 North Moore St.
Arlington, VA 22209
(703) 243-2227, Fax (703) 242-1726



Gravitational Plant Physiology Unit

The Gravitational Plant Physiology Unit is designed to perform two specific gravitational plant physiology experiments, but may be adapted to other gravitropic, phototropic or circumnutational studies.

The culture rotor assembly contains two 1-g centrifuge rotors, each designed to hold 16 plant cubes. The test rotor contains two variable-gravity centrifuge rotors. Each rotor has 16 positions to hold plant cubes. The test rotors operate independently and provide a range from 0-g to 1-g.

The unit provides for time-lapsed photography of the plant seedlings before and after light stimulus.

Operational Characteristics

Capacity:	32 plant cubes
Size:	1 double Spacelab rack, approx. 41.5 in W x 108 in H x 30 in D

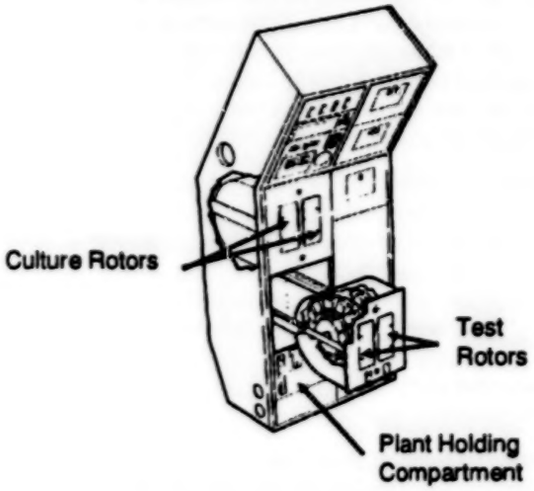
Weight

Culture rotor:	64.7 lbs
Test rotor assembly:	80.5 lbs
Total:	363.7 lbs

Carrier: Spacelab

Available: Now

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736



Initial Blood Storage Experiment Apparatus (IBSE)

When blood is stored on Earth, cell-to-cell and cell-to-container interactions cause sedimentation lesions, which may be harmful to blood elements. Sedimentation causes platelets to settle to the bottom of the container while other blood components die. The IBSE can be used to compare blood components stored in orbit with like blood stored on Earth, thereby improving the understanding of basic blood cell physiology.

The IBSE supports experiments which can evaluate the fundamental cell physiology of erythrocytes, platelets and leukocytes during storage in space in three discrete polymer/plasticizer formulations using standard blood bags.

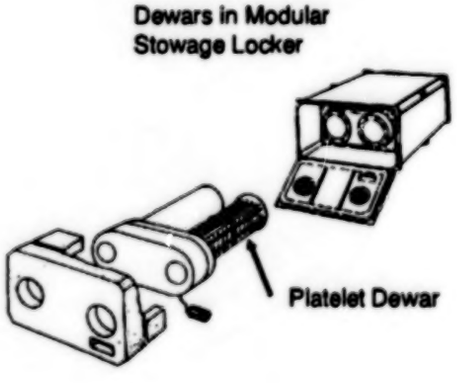
Operational Characteristics

Cold dewar module capacity:	6 standard blood bags: 3-250 ml whole blood, 3-75 ml leukocytes
Warm dewar module capacity:	10 standard blood bags: platelets
Temperature	
Cold dewar:	4° to 6° C
Warm dewar:	21° to 23° C
Size:	44.6 cm L x 39.2 cm W x 18.4 cm H
Weight:	46.4 kg total (both dewars)

Carrier: Shuttle middeck (1 locker)

Available: Now

Contact: NASA/Johnson Space Center
Flight Projects Engineering Office, Code ID
Houston, TX 77058
(713) 282-1830.



Orbiter Centrifuge

The function of the laboratory centrifuge is to perform separations inherent in blood-related life sciences research. The centrifuge provides a minimum relative centrifugal force of 1400 g's when fully loaded. There is an automatic shutdown time that may be manually set for operating durations to 99 minutes in increments of one minute. An override is available so that manual starting and stopping can be initiated without intervention by the timer. The centrifuge is mounted by two suction cups. The head can be modified to accommodate different specimens.

Capacity of Tubes	12 available
Nominal value:	15 ml
Optional value:	10 ml
Outside diameter:	17 mm
Length:	133 mm

Operational Characteristics

Size:	49 cm L x 41 cm W x 23 cm H
Weight:	11.36 kg
Volume:	4.62×10^{-1} cm^3
Time of test:	Variable in 1-minute increments to 99 minutes

Carrier: Spacelab

Available: Now

Contact: NASA/Johnson Space Center
Life Sciences Experiments Program
Houston, TX 77058
(713) 483-7328

Plant Growth Facility Two, PGF-2

The PGF-2 is a small, middeck locker-sized plant growth chamber configured as a simulator of the Lockheed PGU (see Plant Growth Unit, below) flight hardware for low-cost experiment development with small plants or plant parts. The unit is designed for maximum access and flexibility in operation. Construction is sheet metal, fastened with a minimal number of screws, and all major cover panels are attached with 1/4-turn fasteners. Inner dimensions and mounting surfaces are basically the same as the Lockheed PGU with a capacity for six Lockheed Plant Growth Chamber (PGC) plant culture vessels or an equivalent volume (14.5 in W x 8.5 in D x 10.0 in H). The internal volume also is adjustable with respect to height to accommodate developing experiments and experiment-specific instrumentation.

The PGF-2 is controlled by a small, IBM PC XT compatible Intel WildCard-88 based computer with RS-232 communications interface, 640 K bytes of battery-backed static RAM memory, 3.5 inch 1.44 Mbyte floppy disk and handheld terminal with display. It serves also as a data acquisition system with 16 single-ended A/D channels with 12 bit output for temperature control, fluid management, light cycle and sensor inputs. Plant growth lights are in two configurations: a standard light box consisting of three fluorescent tubes in the Lockheed PGU configuration and a unit for higher light requirements in which each PGC is served by a set of three six-watt fluorescent tubes. Thermal control is to +/-.5° C of set point from 1° above ambient to 35° C.

Operational Characteristics

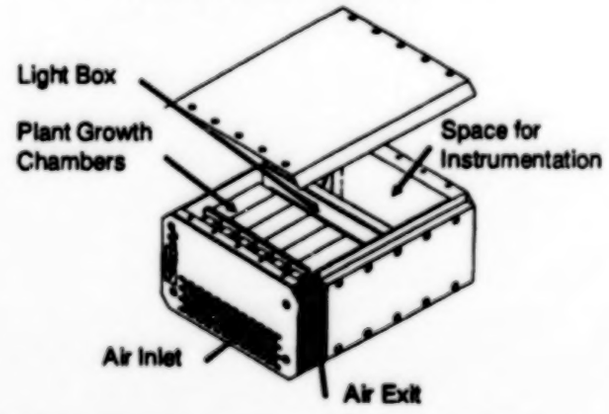
Dimensions:	10.5 in x 18 in x 21 in, (approx. Shuttle locker dimensions)
Volume:	approximately 2 cubic ft
Weight:	45 lbs approximate dependent upon PGC weight
Power:	75 W – 3 tube light configuration 125 W – 18 tube light configuration
Cooling:	above ambient by regulation of air flow

Accessory Equipment: 1. Several configurations of small plastic and aluminum plant growth chambers (PGC). 2. Fluid management module for water, nutrient or atmospheric control in the chambers. 3. Detachable trunions and stand. 4. 28 Volt Shuttle simulator power supply

Carrier: Shuttle middeck locker

Available: Now

Contact: H. W. Scheld, Director of Research
PhytoResource Research, Inc.
707 Texas Ave., Suite 101-E
College Station, TX 77840
(409) 693-8606, Fax (409) 696-3451



Plant Growth Unit (PGU)

The PGU is self-contained and designed to hold six removable plant growth chambers. Each chamber contains 16 seeds and seedlings. The chambers are placed in the PGU where the environment is controlled. Diurnal cycles are adjustable. Temperature is controllable only above ambient.

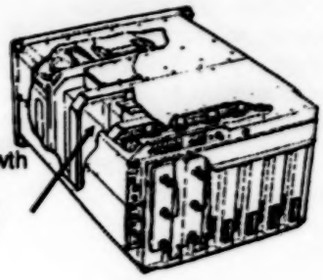
Operational Characteristics

Size:	52 cm L x 45.9 cm W x 27.4 cm H
Chamber size:	19 cm L x 5 cm W x 22 cm H
Weight:	27.2 kg

Carrier: Shuttle middeck locker

Available: Now

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736



Research Animal Holding Facility (RAHF)

The RAHF is a general purpose facility for housing small animals. The unit can accommodate a combination of 24 350-gram rodents or four 1-kg squirrel monkeys. The module provides structural support, air ducts, lights, animal water system components and temperature and humidity sensors. The animals are fed automatically. Waste is collected in removable trays and protection against cross-contamination between crew and animal is provided through bacteriological isolation.

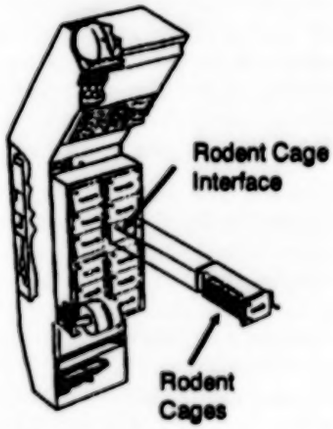
Operational Characteristics

Capacity:	24 350-gram rodents or 4 1200-gram primates
Size:	Approx. 1.5 Spacelab racks 41.5 in W x 108 in H x 29.92 in D
Weight:	About 400 kg

Carrier: Spacelab

Available: Now

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736



Rodent Configuration

Research Animal Holding Facility Primate Cage

The primate cage houses one 1200-gram animal; four cages will fit into the RAHF unit (page 104). The individual cages can contain a primate restraint system, venous and arterial infusion systems with blood-pressure sensor, urine collection system and a feeding and watering system. Water is available and food is dispensed by the subject on a pre-trained program. The unit also may be used to transfer a variety of other biological specimens as required.

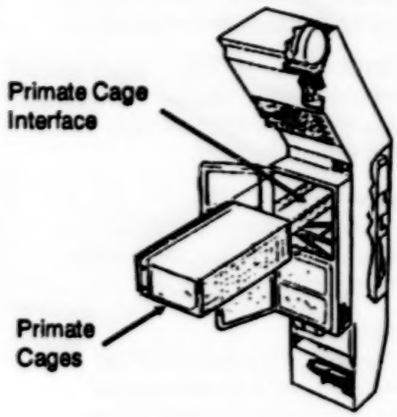
Operational Characteristics

Cage Size:	21.69 cm W x 36.91 cm H x 53.34 cm D
Weight:	18.3 kg (empty)

Carrier: Spacelab

Available: Under development

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffett Field, CA 94035
(415) 604-5736



Squirrel Monkey Configuration

Other Support Equipment Available from Ames Research Center

Ambient Temperature Recorder
This unit is a totally self-contained, battery-operated device that may be placed in any environment to provide a history of its own surface temperature.

Autogenic Feedback System (AFS)
The AFS is an ambulatory physiological monitoring system designed to monitor and record eight human physiological parameters.

Biotelemetry System (BTS)
The BTS is a general-use system to monitor physiological functions of mammals. One to four parameters can be recorded per unit.

Compound Microscope
The compound microscope is a modified Carl Zeiss-type WL unit. It supports cardiovascular investigations and is generally mounted on the General Purpose Work Station in the Spacelab module.

Dissecting Microscope
This microscope supports dissecting investigations and is mounted on the General Purpose Work Station. It is a Zeiss stereomicroscope, Model SV8, with supporting equipment.

Plant Canister
The units are designed to hold 15 corn plants each. They are carried in a foam cutout in the Shuttle middeck locker during launch and then placed in a freezer during the mission.

Primate Biorhythm 8-Channel Recorder
This system consists of transducers and a recorder for measuring skin, deep-body and ambient temperature, and heart rate for two restrained Rhesus monkeys.

Primate Restrain Chair
This chair will maintain a small squirrel monkey under stable physiological conditions. It is intended for use within the Research Animal Holding Facility in the Spacelab module.

Rodent and Primate Activity Monitors
Each rodent and primate cage compartment within the Research Animal Holding Facility contains one activity monitor consisting of an infrared light source and a sensor.

Rodent Restrainer
The restrainer will confine a rat with minimal stress while interperitoreal and tail injections, blood sampling and cardiovascular measurements are performed.

Veterinary Kit
This kit contains provisions that can be used for emergency care of squirrel monkeys and rodents during flight. It is stowed in either the Shuttle middeck or Spacelab.

Contact: NASA/Ames Research Center
Space Life Sciences Payloads Office
Moffet Field, CA 94035
(415) 604-5736

Other Support Equipment Available from Johnson Space Center

GN2 Passive Freezer
This freezer is employed to freeze experiment samples and can keep them frozen until Shuttle landing and recovery.

Pocket Voice Recorder
This is a miniature, pocket-type, battery-powered voice recorder. It is a flight-qualified Olympus Pearlcorder Model E420.

Rail Clamp
This device provides a means of placing hardware or equipment items at a convenient location during non-operating times. It attaches to Spacelab rack handrails.

Contact: NASA/Johnson Space Center
Life Sciences Experiments Program
Houston, TX 77058
(713) 483-7328

Chapter 9: Remote Sensing

Space provides us with a vantage point, a means of drawing away from the Earth to see it as a whole. Satellite studies of our own and other planets provide comparative data that we are using to better understand our world and its solar system. From such studies, we have learned that Earth is unusual in our solar system; it is the one place where both life and liquid water exist. The living and physical components of Earth are involved in a complex interplay of inextricably linked physical, chemical and biological processes. From this global perspective, we have begun to synthesize the dynamic interactions between life and its environment into an integrated concept. Many studies are leading us to ask some very practical questions about the habitability of our own and other solar systems, as we lay the foundation for a new home beyond the familiar confines of our planet.

Operational systems, such as spacecraft, aircraft and ground systems, have provided a wealth of data on Earth resources. A value-added company has the potential of marketing selected sets of data, merged with photographic data or data generated by other sources. An example of this application is the data obtained from the LANDSAT series of satellites, whose wealth of data is marketed by the Earth Observation Satellite Company (EOSAT) (see page 114).

Commercial applications of remote sensing technology are providing valuable information to farmers, mining companies, surface transportation companies, environmentalists and urban planners. Collected and relayed data is used for crop forecasting, forestry, hydrology, mineral exploration, land use management, aquaculture harvesting, navigation aids, weather observation and forecasting, archeological findings and other activities. Observations may be made optically with camera components, or through various wave length modes, such as X-ray or ultra-violet.

Data interpretation, image enhancement and value-added services play as important a role in the remote sensing industry as data collection. Therefore, ground-based research is a widely evolving activity as the requirements and uses of remote sensing data are becoming fully realized. In addition, commercial applications are planned in the testing of advanced sensor technology, large-scale cameras, data relay devices, data reduction techniques and others (see also EOCAP information on page 5).

Remote Sensing Cameras

A-3 Configuration

The A-3 package consists of two HR-732 cameras, each with a 24-inch focal lens cone. This configuration provides for multi-emulsion or multi-spectral coverage of the same ground scene.

Operational Characteristics

Package:	2 HR-732 cameras
Lens data:	24 in f/8.0
Format:	9 x 18 in
Frame coverage @ 65,000 ft:	4 x 8 nmi
Vertical scale @ 65,000 ft:	1:32,000
Nominal ground resolution:	2 ft to 15 ft

Carrier: ER-2 Aircraft

Available: Now

Contact: Gary Shelton
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA 94035-1000
(415) 604-5344

A-4 Configuration

The A-4 package consists of one RC-10 metric camera with interchangeable 6- or 12-inch focal length lens cones and one HR-732 camera with a 24-inch focal length lens cone. This configuration provides for both medium and large scale coverage centered over the same scene.

Operational Characteristics

Package:	1 Wild-Heerbrugg metric RC-10 camera 1 HR-732 camera
Lens data:	6-in f/4.0 (RC-10) 12-in f/4.0 (RC-10) 24-in f/8.0 (HR-732)
Format:	9 x 9 in (RC-10)
Frame coverage @ 65,000 ft:	16 x 16 nmi (RC-10, 6-in) 8 x 8 nmi (RC-10, 12-in) 4 x 8 nmi (HR-732)
Nominal ground resolution:	15-25 ft (RC-10, 6-in) 5-25 ft (RC-10, 12-in) 2-8 ft (HR-732)

Carrier: ER-2 Aircraft

Available: Now

Contact: Gary Shelton
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA 94035-1000
(415) 604-5344

Dual RC-10 Metric Camera System

This package consists of two RC-10 metric cameras with interchangeable 6- or 12-inch focal length cones. This arrangement provides for dual scale or dual emulsion for the same scene.

Operational Characteristics

Package:	2 Wild-Heerbrugg metric RC-10 cameras
Lens data:	6-in f/4.0, 12-in f/4.0
Format:	9 x 9 in
Frame coverage @ 65,000 ft:	16 x 16 nmi (6-in) 8 x 8 nmi (12-in)
Vertical scale @ 65,000 ft:	1:130,000 (6-in) 1:65,000 (12-in)
Nominal ground resolution:	15-25 ft (6-in) 5-25 ft (12-in)

Carrier: ER-2 Aircraft

Available: Now

Contact: Gary Shelton
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA 94035-1000
(415) 604-5344

IRIS II Panoramic Camera

This package consists of an ITEK IRIS II panoramic camera with a 24-inch focal length lens cone. This configuration provides for high resolution, wide-area coverage in mono/stereo modes.

Operational Characteristics

Package:	Itek IRIS II camera
Lens data:	24 in f/3.5
Format:	4.5 x 34.7 in
Frame coverage @ 65,000 ft:	2.0 x 21.4 nmi (90 degree scan)
Vertical scale @ 65,000 ft:	1:32,000
Nominal ground resolution:	1 to 5 ft

Carrier: ER-2 Aircraft

Available: Now

Contact: Gary Shelton
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA 94035-1000
(415) 604-5344

Large Format Camera (LFC)

The Large Format Camera (LFC) is a special mapping camera built for NASA to meet the demands of performance at orbital altitudes. The LFC primary mode of operation is to provide precise vertical stereoscopic photographic imagery of the Earth in a wide-field synoptic mode at very high resolution. The LFC is a precision cartographic camera with high geometric fidelity and has an advanced image motion compensation mechanism. It has a 305 mm image format with the long dimension oriented in the direction of flight. The LFC has been mounted in the Shuttle's cargo bay but also may be mounted in a free flying spacecraft or in an aircraft.

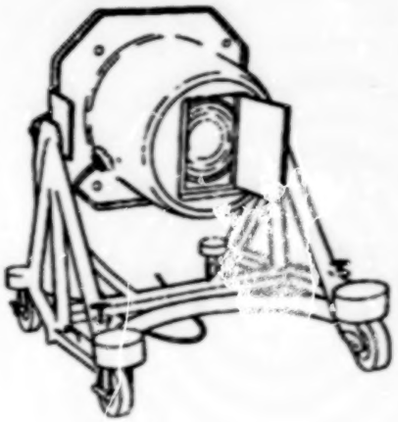
Operational Characteristics

Focal length:	30.5 cm
Aperture:	f/6
Film capacity:	2,400 frames
Weight:	340 kg
Resolution:	80 lines/mm (about 20 m at operational altitudes)

Carrier: Learjet, Shuttle cargo bay

Available: Now

Contact: NASA/Stennis Space Center
Commercialization Branch
Science and Technology Laboratory
Stennis Space Center, MS 39529
(601) 688-2042



Remote Sensing Scanners

Aerial Data Acquisition Program

The Aerial Data Acquisition program uses a Daedalus 1260 Multispectral Scanner (DMS). This scanner offers one broad thermal infrared, one near infrared and 8 visible bands. Types of studies and projects where multispectral scanner data can contribute vital information include:

Detection and mapping: thermal effluents, coal refuse fires, surface faults and fractures

Detection of: rooftop heat loss and moisture damage, problems in buried streamlines, condensate return hot water lines

Detection and monitoring: dam and levee seepage; ground water discharges into lakes, rivers and oceans; sewage diuposal pollution into waterways

Studies: water dynamics, site selection, satellite support, cooling pond efficiency and seepage

Carrier: Learjet

Available: Now

Contact: George A. May
ITD Space Remote Sensing Center
Building 1103, Suite 118
Stennis Space Center, MS 39529
(601) 688-2509

Airborne Ocean Color Imager

The Airborne Ocean Color Imager (AOCI) is a high altitude multispectral scanner designed for oceanographic remote sensing. It provides 10-bit digitization of eight bands in the visible/near-infrared region of the spectrum, plus two 8-bit bands in the near and thermal infrared. The bandwidths are as follows:

Channel	Wavelength, *um*
1	0.436-0.455
2	0.481-0.501
3	0.511-0.531
4	0.554-0.575
5	0.610-0.631
6	0.655-0.676
7	0.741-0.800
8	0.831-0.897
9	0.989-1.054
10	8.423-12.279

Sensor/aircraft parameters

Instantaneous Field of View:	2.5 mrad
Ground Resolution:	163 ft (50 meters at 65,000 ft)
Total Scan Angle:	85°
Swath Width:	18nmi (33.3 km)
Pixels/Scan Line:	716
Scan Rate:	6.25 scans/second
Ground Speed:	400 kts (206 m/second)

Carrier: ER-2 Aircraft

Available: Now

Contact: Gary Shelton
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA
(415) 604-6252

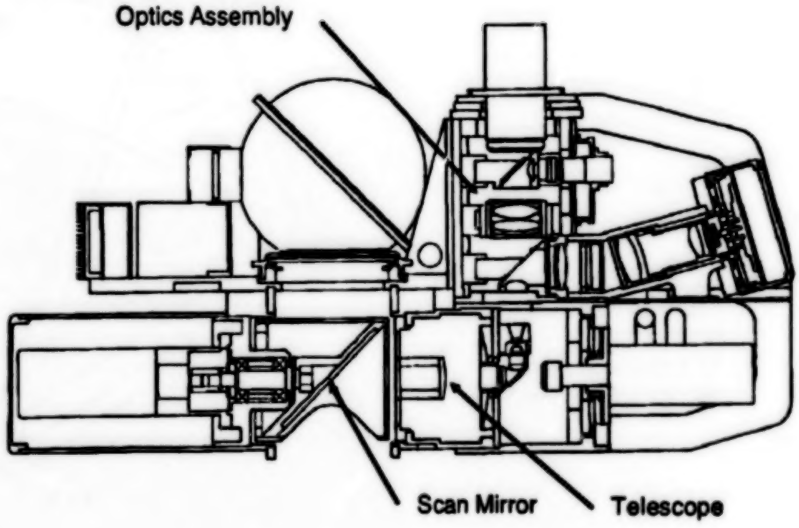
Calibrated Airborne Multispectral Scanner (CAMS)

The CAMS is a nine-channel, airborne imaging device that samples electromagnetic energy in several spectral regions. Scan speeds are adjustable from 6 to 80 scans per second in one-scan increments, providing an instantaneous field-of-view angle of 100 degrees. All channels of data contain information derived from onboard references. During data acquisition, each reference source is viewed by the CAMS and the appropriate information is recorded for later use. For a typical data acquisition mission at an altitude of 2 kilometers above terrain elevation, the pixel size is 5 meters on a side of 2.33 kilometers.

Carrier: Learjet

Available: Now

Contact: NASA/Stennis Space Center
Commercialization Branch
Science and Technology Laboratory
Stennis Space Center, MS 39529
(601) 688-2042



NS001 Multispectral Scanner

The NS001 Multispectral Scanner (MS), flown on the C-130B aircraft, contains the seven LANDSAT-D Thematic Mapper bands plus a band from 1.13 to 1.35 micrometers. The specific bands are as follows:

Band	Spectral bandwidth, *um*
1	.458-.519
2	.529-.603
3	.633-.697
4	.767-.910
5	1.13-1.35
6	1.57-1.71
7	2.10-2.38
8	10.9-12.3

Sensor specifications

Instantaneous Field of View:	2.5 mrad
Total Scan Angle:	100 degrees
Pixels/Scan Line:	699

The format of the flight data consists of 838 eight-bit words per frame (data for one wavelength band throughout a scan line). Of these, 699 are the video information and the remainder are information on Greenwich time, scan line number, calibration lamp voltage and current, blackbody temperatures, etc.

Carrier: C-130 Aircraft

Available: Now

Contact: Rube Erickson
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA 94035-1000
(415) 604-5344

Thematic Mapper Simulator

The Daedalus Thematic Mapper Simulator (TMS) is a high altitude multispectral scanner, flown aboard NASA's ER-2 aircraft. It simulates spatial and spectral characteristics of the seven LANDSAT-D Thematic Mapper bands. The specific bands are as follows:

Daedalus

Channel	TM Band	Wavelength, *um*
1	A	0.42-0.45
2	1	0.45-0.52
3	2	0.52-0.60
4	B	0.60-0.62
5	3	0.63-0.69
6	C	0.69-0.75
7	4	0.76-0.90
8	D	0.91-1.05
9	5	1.55-1.75
10	7	1.55-1.75
11	6	8.5-14.0 low gain
12	6	8.5-14.0 high gain

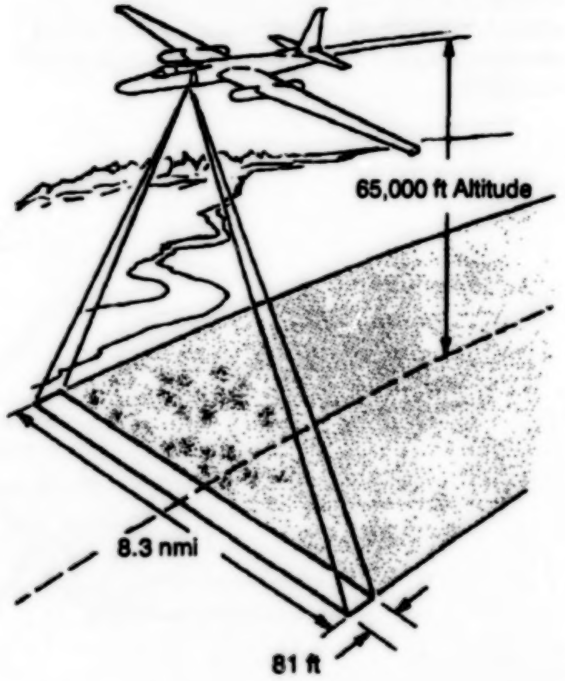
Sensor/aircraft parameters

IFOV:	1.3 mr
Ground Resolution:	91 ft (28 meters at 70,000 ft)
Total Scan Angle:	43°
Swath Width:	9.0 nmi (16.6 km at 70,000 ft)
Pixels/Scan Line:	716 (750 following rectification)
Scan Rate:	12.5 scans/second
Ground Speed:	400 kts (206 m/second)

Carrier: ER-2 Aircraft

Available: Now

Contact: Gary Shelton
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA 94035-1000
(415) 604-6252 or 604-5344



Thermal Infrared Multispectral Scanner (TIMS)

The Thermal Infrared Multispectral Scanner (TIMS) is an experimental system developed by the Jet Propulsion Laboratory and Daedalus Corporation. The TIMS is flown frequently on C-130 missions and has been adapted for use on ER-2 high altitude aircraft. The sensor collects thermal data in six discrete channels of the spectrum from 8.2 um to 12.2 um. Used as an airborne geologic remote sensing tool, the TIMS collects mineral signature data which permits the discrimination of silicate rocks, carbonate rocks and hydrothermally altered rocks. The TIMS has acquired geologic data over Big Horn Basin, WY, and volcanology data over the island of Hawaii and the Cascade Range in Washington, Oregon and California. The TIMS instrument is configured as follows:

Channel	Wavelength, *um*
1	8.2-8.6
2	8.6-9.0
3	9.0-9.4
4	9.4-10.2
5	10.2-11.2
6	11.2-12.2

Sensor specifications

Instantaneous Field of View:	2.5 mrad
Scanner Field of View (FOV):	76.56°
Ground Resolution:	25 ft (7.6 m at 10,000 ft aircraft attitude)
Pixels/scan line:	698
Swath width:	2.6 nmi (4.8 km at 10,000 ft aircraft attitude)
Scan rates:	7.3, 8.7, 12, and 25 scans/second (selectable)

Carrier: ER-2 Aircraft

Available: Now

Contact: Rube Erickson
High Altitude Missions Branch
NASA/Ames Research Center, MS 240-6
Moffett Field, CA 94035-1000
(415) 604-5344

Other Remote Sensing Equipment and Services

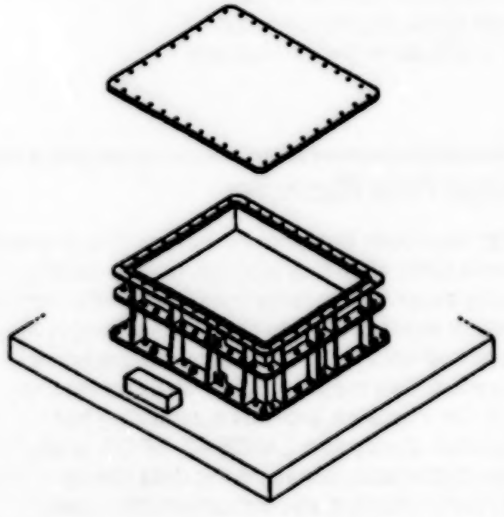
Cosmic Ray Determination (Nuclear Track Detectors)

The hardware consists of a stack of plates (X-ray film) 400 x 500 x 194 mm (typical plate thickness is 1 to 2 mm) enclosed in an aluminum chamber. A self-contained data logger powered by its own internal battery pack is employed as part of the experiment. This unit can function on a variety of carriers.

Operational Characteristics

Size:	522 x 592 x 222 mm
Weight:	229 kg
Power:	Entirely passive
Carrier:	To be determined

Contact: Francis C. Wessling
Consortium for Materials Development in Space
University of Alabama in Huntsville
Research Institute Building, Room M-65
Huntsville, AL 35899
(205) 895-6620



Earth Observation Satellite Company (EOSAT)

The Earth Observation Satellite Company (EOSAT) markets data from the LANDSAT series of satellites. The LANDSAT archive contains over 2.5 million images, 185 x 170 km in size. The primary data source is the Thematic Mapper (TM) instrument, which records seven measurements for every quarter-acre of land.

TM data are available in two product lines; digital products and photographic products. EOSAT also markets RSVGA, a software package for use with the floppy disk digital product.

Digital Products

Geocoded Products
9-track computer compatible tape
6250 Bpi
Any USGS-supported map projection
Choice of Earth ellipsoid
Choice of pixel size (from 25 to 240 meters)
Full scenes, 185 x 170 km
Quadrant scenes, 100 x 100 km
Map sheet, 1/2° x 1°

Standard Products
9-track computer compatible tape
6250 Bpi (1600 Bpi with surcharge)
SOM or UTM/PS projection
International 1967 Earth ellipsoid
28.5 meter pixels
Full scenes, 185 x 170 km
Quadrant scenes, 100 x 85 km
Movable sub-scenes, 100 x 100 km
Movable mini-scenes, 100 x 50 km or 50 x 100 km

Floppy disk products
360K, 5.25 inch disks
MS/DOS and PC/DOS format
Seven disks, one band per disk
512 x 512 pixels (14.6 x 14.6 km)

Photographic Products, Color

Full scene	
Positive transparency	1:1,000,000 scale
Paper prints	1:1,000,000 scale
	1:500,000 scale
	1:250,000 scale
Quadrant scene	
Positive transparency	1:500,000 scale
Paper prints	1:500,000 scale
	1:250,000 scale
	1:100,000 scale
Quad-of-a-quad	
Paper prints	1:50,000 scale

Data Search Service

A free search of LANDSAT data of a particular area is available by request from the EOSAT Customer Services Department. Areas of interest may be specified as follows (one of three ways):

- latitude and longitude coordinates for the center point or the corners of the area
- path/row designation in the Worldwide Reference System (path/row maps are also available free of charge from Customer Services)
- name of a major geographic feature, such as a city

When requesting a data search, specify maximum acceptable cloud cover, year and time of year desired and minimum quality rating acceptable.

Contact: EOSAT Customer Services
4300 Forbes Boulevard
Lanham, MD 20706
(301) 552-0537, Fax (301) 552-0507
(800) 344-9933 USA, Canada,
Virgin Islands

Image Film Recorder

A high resolution film recorder with variable size and gamma control flexibility provides remote sensing images as received directly from the satellite sensor or image enhanced/processed scenes. Images may be stacked within a frame for easy comparison and evaluation. This recorder, based on direct electron beam film exposure, provides outstanding first generation quality from LANDSAT, SPOT, et al., image digital data. Stereographic data can be recorded to match stereo instrumentation used.

Recorder Characteristics

Film width:	5 in
Resolution:	4 to 16 micrometers
Gamma:	.5 to 2
Density:	0.05 to 3.0 du
Polarity:	Positive or Negative

Available: Now

Contact: Putnam Morgan
Image Graphics, Inc.
917 Bridgeport Avenue
Shelton, CT 06484
(203) 926-0100

METPRO

METPRO is a professional atmospheric and meteorological information processing system. METPRO processes real-time data from geostationary and polar-orbiting weather satellites, weather radar, conventional surface and upper-air sensor, lightning detection systems and wind profiler networks.

METPRO is capable of supporting turn-key data capture, processing and data product development. The heart of the METPRO system is its user-friendly applications software package. The NASA-developed Transportable Applications Executive Plus (TAE+) provides a transparent interface to functions. METPRO's perspective and 3-D imagery supplement standard maps and fully integrated image products. METPRO is modular in design and can be customized to meet the user's needs.

METPRO performs more than 100 parametric calculations, including:

- potential temperatures and mixing ratios
- geopotential height and geostrophic wind
- horizontal divergence and relative vorticity
- convective condensation levels and stability indices
- total precipital water
- specific and relative humidity
- thermodynamic functions

Available: Now

Contact: Edward J. Hurley
Business Development
General Sciences Corporation
6100 Chevy Chase Drive, Suite 200
Laurel, MD 20707
(301) 953-2700

Observer Remote Sensing Satellite

OBSERVER is a small, commercial remote sensing satellite that is designed to provide wide coverage, high resolution Earth images in the 0.5-0.73 spectral band. The baseline design for the satellite fits the Pegasus launch vehicle (see page 207).

OBSERVER'S payload consists of two modified Schmidt cameras with linear charge coupled device (CCD) image sensors. The CCD's are staggered at the focal plane, along the pitch axis, to provide continuous swath imaging, in a push broom fashion. Image scanning is accomplished electronically by operating the proper set of CCD's; OBSERVER, therefore, has no mechanically moving parts. Patented image compression hardware and software are implemented on board the spacecraft allowing up to 12:1 image compression and reducing the data storage, downlink bandwidth and power requirements. (See illustration, page 116.)

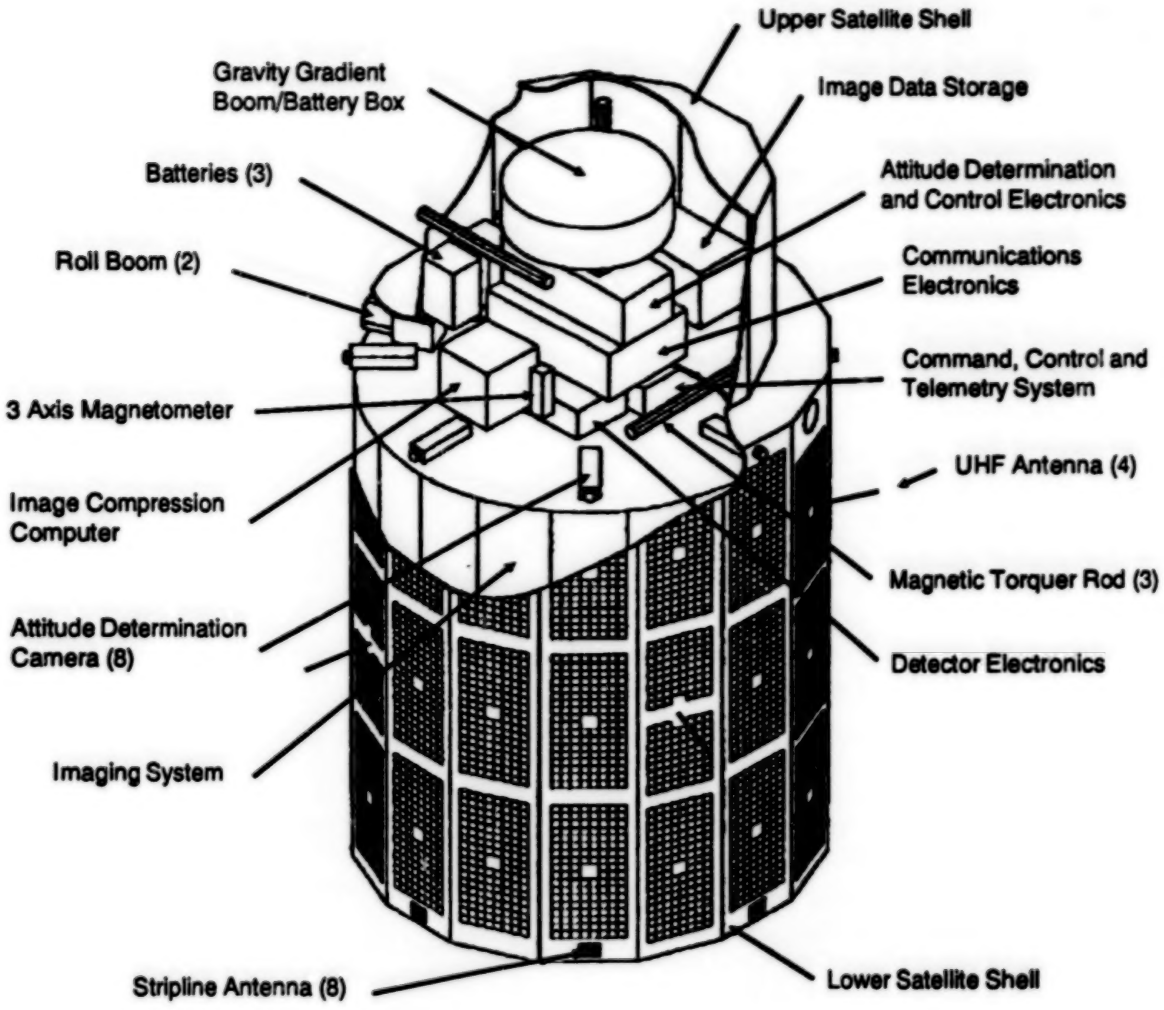
Operational Characteristics

Mass:	200 kg
Shape & Dimension:	16 side-cylinder, 42 inches in diameter stepped in at 52 inches to a 12 side-cylinder 32 inches in diameter and 18 inches long
Power:	Average 85 watts
Attitude control:	+/-2°
Attitude determination:	+/-0.1°
Thermal control:	Passive
Temperature range:	Near room temperature
Orbit:	700 km altitude, Polar orbit
Coverage:	98% coverage every 3 days 100% coverage every 5 days
Field of View:	53°
Resolution:	5 meters
Swath width:	700 km
Image size (frame):	60 km x 60 km
Number frames/day:	200

Available: Now

Contact: Bill Claybaugh
Globesat, Inc.
1740 Research Park Way
Logan, UT 84321
(801) 753-2303

Observer Remote Sensing Satellite (continued)



Chapter 10: Support Equipment and Products

As flight hardware and experiment equipment is being developed, tested and flown, additional secondary pieces of hardware have evolved in support activities. Foremost among these are a number of measurement and recording devices designed to support manned flight experiments.

Several NASA Centers have developed devices which can be adapted for many applications to commercial experiments in space. Several companies also offer interfaces, measurement and recording equipment for experimental apparatus, some of which provide the needed channels of data to assure experiment operations and verification or to lessen the load on the Shuttle facilities.

Computers and Related Equipment

3M Generic Electronic Module (GEM/2)

The GEM/2 is a general purpose, process control and data acquisition computer that supervises and operates payloads flown on any crew-tended space system or unmanned space platform. Any experiment requiring a high-level microprocessor can be supported by the GEM/2, which is based on a VME bus Motorola 68020 format. Hardware options include A/D converters, 32 bit digital I/O, serial ports 20 Megabyte hard disk, 4 Gigabyte mass memory for data storage, DC/DC converters and a PGSC interface for crew interaction. The GEM/2 is housed in a sealed container, has an integral heat exchanger, replaces one middeck locker and mounts to the standard NASA payload mounting panel.

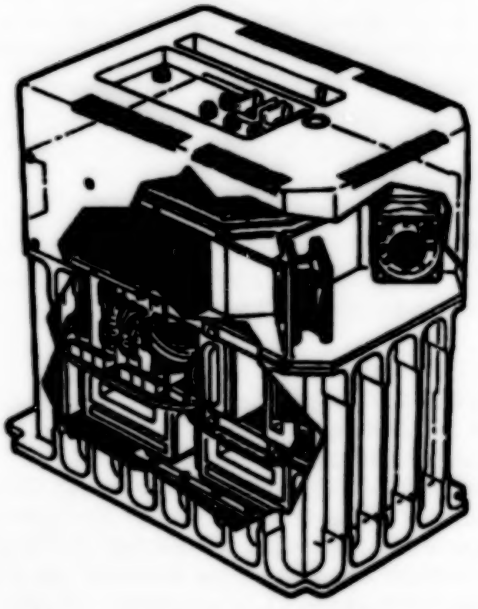
Operational Characteristics

Power:	140 W
Size:	one middeck locker space
Weight:	29.2 kg plus PMP

Carrier: Shuttle middeck or Spacelab

Available: Now

Contact: E. L. Cook
3M Space Research and Applications
Laboratory, Building 201-2N-19
3M Center
St. Paul, MN 55144
(612) 733-4357



Computational Materials Laboratory

This laboratory specializes in modeling and predicting the effects of gravitationally driven convection on crystal growth from the liquid and vapor. It has considerable computing power based around a set of local engineering workstations and a supercomputer shared by the research center.

Hardware

File Server:	Sun 4/260 4 MBy file server with 4 GBy of mass storage space
Workstations:	12 Sun 4/110 workstations or SPARCstations with graphics display hardware

Graphics
Silicon Graphics Workstation
3/4 inch videotape animation recorder and controller
16 mm animation camera
High resolution color printers

Software
General Purpose modified transport codes: NEKTON, FIDAP, FLUENT
Scientific libraries
Graphics Packages
Animation and rendering software
Customized code for specific problems

Carrier: Designed for ground-based research only

Available: Now

Contact: Thomas K. Glasgow
Processing Science & Technology Branch
NASA/Lewis Research Center
21000 Brookpark Road, MS 105-1
Cleveland, OH 44135
(216) 433-5014

Data Logging Engines

The Tattletale line of low power data logging engines are designed to minimize the cost and development of a portable controller/logger. The all-CMOS design is ideal for battery-based applications, while the TTBASIC or TXBASIC operating system permits operation and program development from any terminal computer. Each Tattletale features:

- Analog and digital I/O, including UART, individually programmable I/O lines, counter, square wave generator and three-wire RS-232 serial interface
- CMOS SPU, 32K to 256K of CMOS RAM for storing programs and logging data and EPROM or battery-backed RAM for non-volatile program storage
- Data storage for storing the results of measurements or received data
- Voltage regulator, for connecting the board directly to a battery unregulated source

The Tattletale's TTBASIC operating systems simplifies application software, reducing development time. Its 32-bit integer math allows precision calculations without sacrificing speed. The new, powerful TXBASIC, available for the models 2B and 6, includes two parts: a tokenizer/compiler/assembler that runs on a host machine (Macintosh or PC) and the TXBASIC interpreter in the Tattletale. It is dual tasking and features a fully integrated multi-pass symbolic assembler, which is source code compatible with conventional stand-alone cross-assemblers.

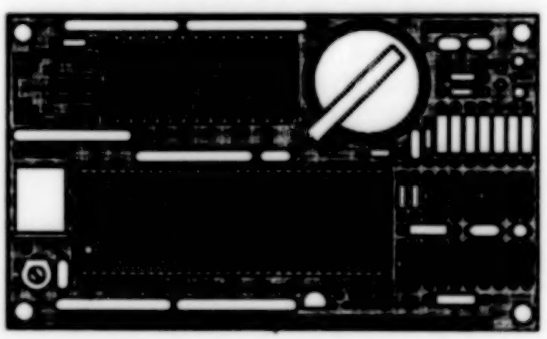
Signal conditioning electronics can be built on an interface board that mounts directly above each Tattletale, connecting to pin strips on the board that bring up power and the digital and analog I/O lines. All Tattletales permit access to the board's internal bus for applications that require substantial hardware expansion.

Operational Characteristics

Size	
Model V	1.4 in x 2.0 in x 0.8 in to
Model 6/200MByte	4 in x 6 in x 2.5 in
Weight	
Model V	1 oz to
Model 6/200 MByte	2 lbs
Current Drain	
Operating:	3-24 MA;
Lower power modes:	30 uA-200uA

Available: Now

Contact: Onset Computer Corp.
199 Main St.
North Falmouth, MA 02556
(508) 563-9000, Fax (508) 563-9477



Graphics System – Satellite Tool Kit (STK)

Satellite Tool Kit is a two-dimensional graphics system for computing, displaying and analyzing satellite, aircraft, ship and terrestrial vehicle paths. Satellite orbits are calculated using a 2-body Keplerian ephemeris generation technique while other ground tracks are produced using great-circle arc algorithms. Alternatively, the track data may be generated by other sources, and displayed and analyzed using the Satellite Tool Kit. STK computes and displays vehicle antenna, sensor swaths and line-of-sight in-view periods. Computed data may be displayed graphically and/or textually at the workstation. The data can be displayed in polar or cartesian coordinates and in all common units. Ground stations, launch sites, targets and other Earth-fixed objects can be displayed on the map using icons and/or target boundaries. Version 1.2 adds solar terminator, sub-solar point and bearing, elevation and range calculation, as well as enhances many capabilities.

Equipment Requirements: runs on Sun Microsystems Sun3, Sun4 and SPARC computers and NeXT computers.

Carrier: Designed for ground-based use

Available: Now

Contact: Paul Graziani
Analytical Graphics, Inc.
P.O. Box 1206
King of Prussia, PA 19406
(215) 337-3055

Imaging Workstations (Corabi)

Corabi International Telemetrics is a telemedicine company that produces imaging workstations for such medical disciplines as pathology, radiology and internal medicine plus biological and other research applications. The workstations include specialized software for the robotic control of microscopes, dynamic HDTV imaging and digital freeze-frame technologies.

Carrier: Ground-based and Space Station applications

Available: Now

Contact: Ann Regan-Jean, Vice President, Marketing
Corabi International Telemetrics
890 South Pickett St.
Alexandria, VA 22304
(703) 823-4753

NPS 2000 Image Processing Integrated Circuit

The Neighborhood Processing Stage (NPS) 2000 implements high-performance machine vision and image analysis functions. Image data may be treated in several different ways by the NPS 2000: as eight independent binary bit-planes, as multiple bit-plane encoded states, as 8-bit greyscale images or as three-dimensional "range image" screen representations. A completely pipelined 20 MHz system is capable of continuous video-rate (60 frames per second for 512 x 512 images, 20 frames per second for 1K x 1K images) processing. Also available as a VME bus plug-in module for the SUN-3 or SUN-4 workstations.

Carrier: For ground-based research

Available: Now

Contact: David L. McCubbrey
Environmental Research Institute of Michigan (ERIM)
P.O. Box 8618
Ann Arbor, MI 48107-8618
(313) 994-1200

Orbiter Display Unit

The Orbiter Display Unit is a high-brightness CRT, 5 x 7 inches, qualification-tested for Shuttle applications.

Available: Now

Contact: Norden Systems Inc.
P.O. Box 5300
Norwalk, CT 06856

SC-2/SC-3 Spaceflight Computers

The SC-2 and SC-3 computers are flight-qualified units that make use of the 80C86/8087 (SC-2) and 80386/80387 (SC-3) processor combinations. These computers are constructed as a simple card cage that can hold up to 16 bus-oriented interface cards. All computer functions, including CPU, memory, timers, interrupts and input/output are implemented using these plug-in cards. The modular design provides flexibility and economy in configuring each unit to accommodate specific user requirements. Most internal circuits utilize CMOS circuitry and high levels of integration, which contribute to small overall size and low power consumption. The SC-2/SC-3 computers are most useful when ease of configuration or high-speed processing are important to the user.

Operational Characteristics

Central Processor:	80C86/8087 (SC-2), 80386/80387 (SC-3)
Clock Frequency:	8 MHz (SC-2), 12 MHz (SC-3)
Operating System:	various available
Expansion Cards:	Memory with EDC (EEPROM, UVPROM, and RAM)

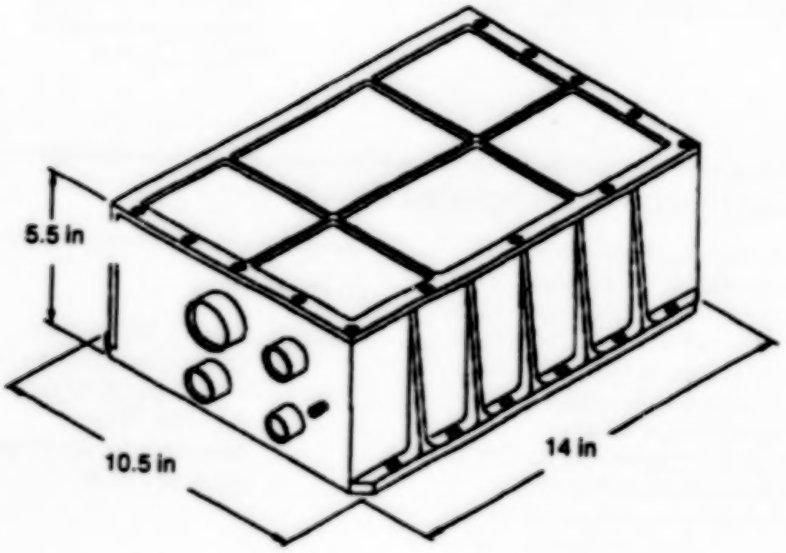
Parallel Input/Output
MIL-STD 1553 Interface
Serial Communications (RS-232, 422, and 485)
High Rate Multiplexer I/F
Remote Acquisition Unit I/F
D/A and A/D Conversion
Timer/Interrupt
Custom Interface Configurations

Size:	14 in x 10.5 in x 5.5 in
Weight:	16 lb (approximate)
Power:	28V @ 25W (approximate)

Carrier: Shuttle cargo bay, freeflyer, Space Station

Available: Now

Contact: Mark V. Muller, Senior Research Engineer
Southwest Research Institute
Instrumentation & Space Research Division
6220 Culebra Road, Div. 15
San Antonio, TX 78228-0510



SC-4 Spaceflight Computer

The SC-4 is a flight-qualified computer designed specifically as an experiment controller for use in middeck lockers of the Shuttle. This 10 MHz, 80C186-based computer has the ability to run either the MS-DOS or VRTX operating systems. Standard capabilities include multiple interrupts and user programmable counters, direct processing of analog and digital signals and on-board access of up to 24 Mbytes of error detect/correct memory. Several types of interface ports are available in the standard configuration and additional expansion is available through the use of an internal daughterboard connector. All of these features reside in a notebook-size package that weighs about 5 lbs, uses only 5 watts of power and costs less than conventional units.

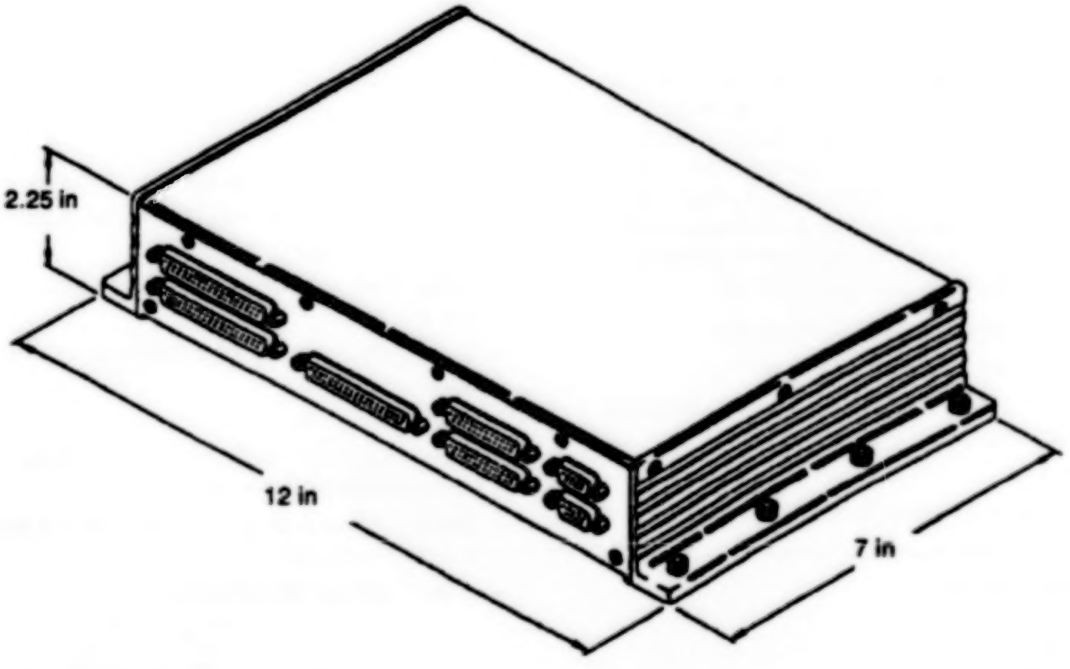
Operational Characteristics

Central Processor:	80C186/80C187 16 Bit
Clock Frequency:	10 MHz
Operating System:	MS-DOS and VRTX Compatible
Onboard Memory:	RAM: 512 Bytes w/EDC; EEPROM: 256K Bytes w/EDC; UVPROM: 64K Bytes w/EDC
Hardware Vectored Interrupts:	16 user configurable
Timer/Event Counters:	8, software configurable, 120 ns granularity
Input/Output# Capability:	Parallel I/O: 16 Input, 16 Output; Analog Input: 32 Channels, 12-bit Resolution; Analog Output: 4 Channels, 12-bit Resolution
RS-422 Serial I/O:	2 Channels
SCSI Interface:	1 Port
Software Controlled Power Switch:	4 Each
Mass Storage	24M Bytes, Read/Write Non-volatile
Expansion:	Internal Daughterboard Connector
Size:	7 in x 12 in x 2.25 in
Weight:	5 lb (approximate)
Power:	28V @ 5W (approximate)

Carrier: Shuttle-middeck locker, cargo bay, freeflyer, Space Station

Available: Now

Contact: Mark V. Muller, Senior Research Engineer
Southwest Research Institute
Instrumentation & Space Research Division
6220 Culebra Road, Div. 15
San Antonio, TX 78228-0510



SensorNet Experiment Computer (SEC)

Shuttle middeck and Spacelab experiments benefit from the use of the SensorNet Experiment Computer (SEC) for experiment control, data acquisition and storage. Space-qualified in the 1990s, the SEC is designed to control the Middeck Zero-G Dynamics Experiment (MODE), acquire digital and analog data, and store the data to a write-once, read-many (WORM) optical side drive with 200 Mbytes of storage per cartridge. For Spacelab use, a High Rate Multiplexer (HRM) interface module is available for real-time downlink of experiment data.

Standard configurations of this distributed processing modular computer are available for experiment control with analog and digital data acquisition and storage. Other I/O options include: IEEE-488, RS-232, SCSI modules, Analog Output and Digital Signal Processing. The system operates with embedded system software for real-time operations. Experiment control and application development libraries together with an integrated debugging environment assure quality software development.

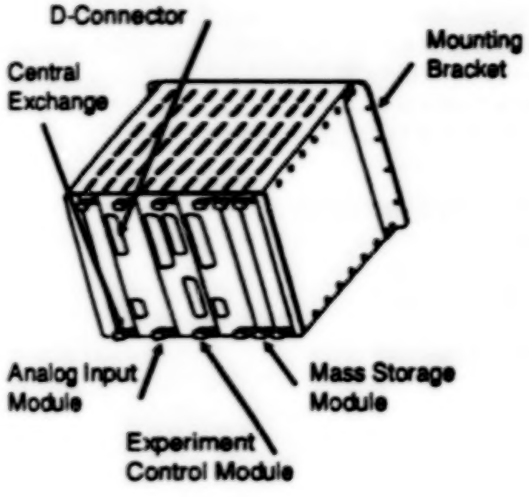
Operational Characteristics

Dimensions:	5.750 in H x 8.625 in W x 7.750 in D
Volume:	384.35 cu in
Weight:	7.25 lbs
Power:	14 watts; 36 watts with WORM drive
Cooling:	Forced Convection

Carrier: Shuttle middeck locker, Spacelab

Available: 1991-92

Contact: Payload Systems, Inc.
276 Third Street
Cambridge MA 02142
(617) 868-8086



SoMat 2000 Field Computer

The SoMat 2000 Field Computer is a microprocessor-based digital data acquisition system designed for easy data collection in a variety of test environments. A basic system consists of a processor module, power and communications module and the Test Control Software (TCS) to setup, calibrate and display data. Users may choose from several different signal conditioning/data acquisition modules to add to the system and configure it accordingly.

A basic SoMat 2000 system includes:

- SoMat 2000 Processor base unit
- Power/Communications module (including three 9-volt batteries)
- Top cover
- Modules (e.g., signal conditioning, memory, filter)
- Cables: serial, power, transducer
- Spare parts kit
- SoMat II Test Control Software (both 5.25 and 3.5 diskettes)
- SoMat II Test Control User's Guide

Important features of the system include:

- Stand-alone operation for unattended long-and short-term data acquisition
- Menu-driven software for easy test setup, operation and analysis
- Modular hardware for expandable memory and signal conditioning
- Multiple channels
- Low power consumption for internal or external battery-powered operation
- Small, portable size (2 in x 3 in x 5 in) in a rugged aluminum package
- IBM-PC compatible software

SoMat 2000 Field Computer (continued)

Hardware
The SoMat 2000 Hardware is a series of stackable computer modules arranged in a bus-like architecture and packaged in an aluminum case for rugged field testing applications. The user can configure a system from an array of standard modules:

- Processor
- Power/Communications
- Strain Gauge Signal Conditioning
- Analog Transducer
- Pulse Counter
- Digital Input/Output
- Programmable Filter
- Extended Memory

An initial SoMat 2000 System is expandable by adding one or more modules as testing needs grow. Provisions have been made for safe shut-down and restarting in the event of power failure, and memory is backed up with a separate battery so that no data is lost. Power is automatically shut off to any transducer in which a short circuit is detected so that the system can continue to function on the remaining channels. The SoMat 2000 was specifically designed with features required for the rugged conditions encountered in field testing.

Operational Characteristics

Weight:	0.6 lbs (260 grams) per module
Module Dimensions:	3 in x 4.25 in x 0.375 in (76 mm x 108 mm x 9.5 mm)
Battery Power:	up to 1000 mA at +5 V
Backup battery life:	2.5 years
Operating temperature:	-20 to +70° C
Vibration:	10-2000 Hz up to 60 g's loading

5-volt excitation to transducer; pulsed and steady
Internal 350 Ohm completion resistors
Low pass programmable filtering
Remote start/stop and event detection
Automatic software controlled zero and gain adjust
Data
collect, store, transfer and protect
Sample rate up to 5000 samples/sec/channel
High-speed low-power CMOS RAM
Data transfer rate up to 57,600 baud
RS 232C interface

SoMat II Test Control Software (TCS)
The SoMat II Test Control Software program (TCS) is an easy-to-use, menu-driven interface between the user, the SoMat 2000 Field Computer, and an IBM-compatible PC. TCS can set up a test; initialize hardware; calibrate transducers; select data acquisition modes; start and stop a test; collect and store test data; manipulate test data; upload data to a larger computer; and display test results (real-time if necessary).

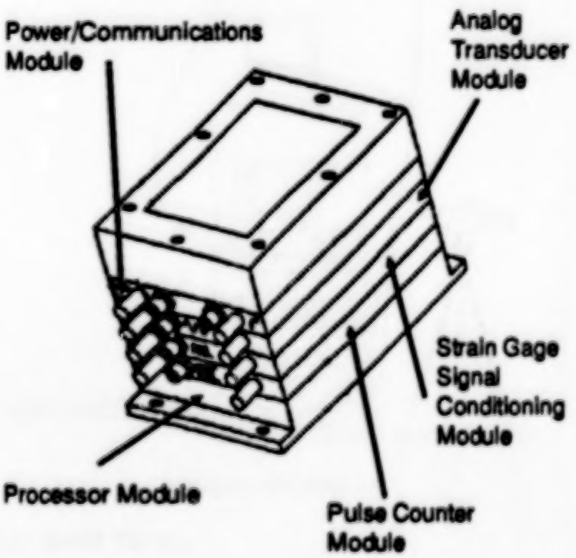
TCS is intuitive and organized in the order of a typical field test, requiring no special programming skills to operate. The program allows the user to select data acquisition modes from a library including: time history, burst time history, sequential peak valley, time at level matrix, rainflow matrix and peak/valley matrix. Multiple data modes may be used simultaneously on the same or different channels.

To run TCS on an IBM PC or compatible, the computer must meet all of the following requirements:

- IBM PC/AT compatible
- 640K RAM
- Video graphics card (e.g., CGA, MCGA, Hercules, EGA, VGA)
- Serial port
- Printer port (optional)
- 2 disk drives, one of which is at least 720K

Available: Now

Contact: Scott Pickard, Vice President
SoMat Corporation
702 Killarney
Urbana, IL 61801
(217) 328-5359



Spacelab Experiment Interface Device (SEID)

The SEID simulates electrical and logical connections of the Spacelab Remote Acquisition Unit to provide experiment and Spacelab hardware/software verification.

Available: Now

Contact: Teledyne Brown Engineering
Cummings Research Park
Huntsville, AL 35807-5301
(205) 726-5613

Telescience Testbed

The telescience testbed is designed to allow researchers to estimate the communications requirement for materials science experiments that are candidates for being teleoperated. Model experiments can be remotely observed and controlled from either on site or from an experimenter's home laboratory.

Equipment
Computers: IBM/AT compatible computers with Video Digitizers IEEE-488 interface
Stepper-motor controller

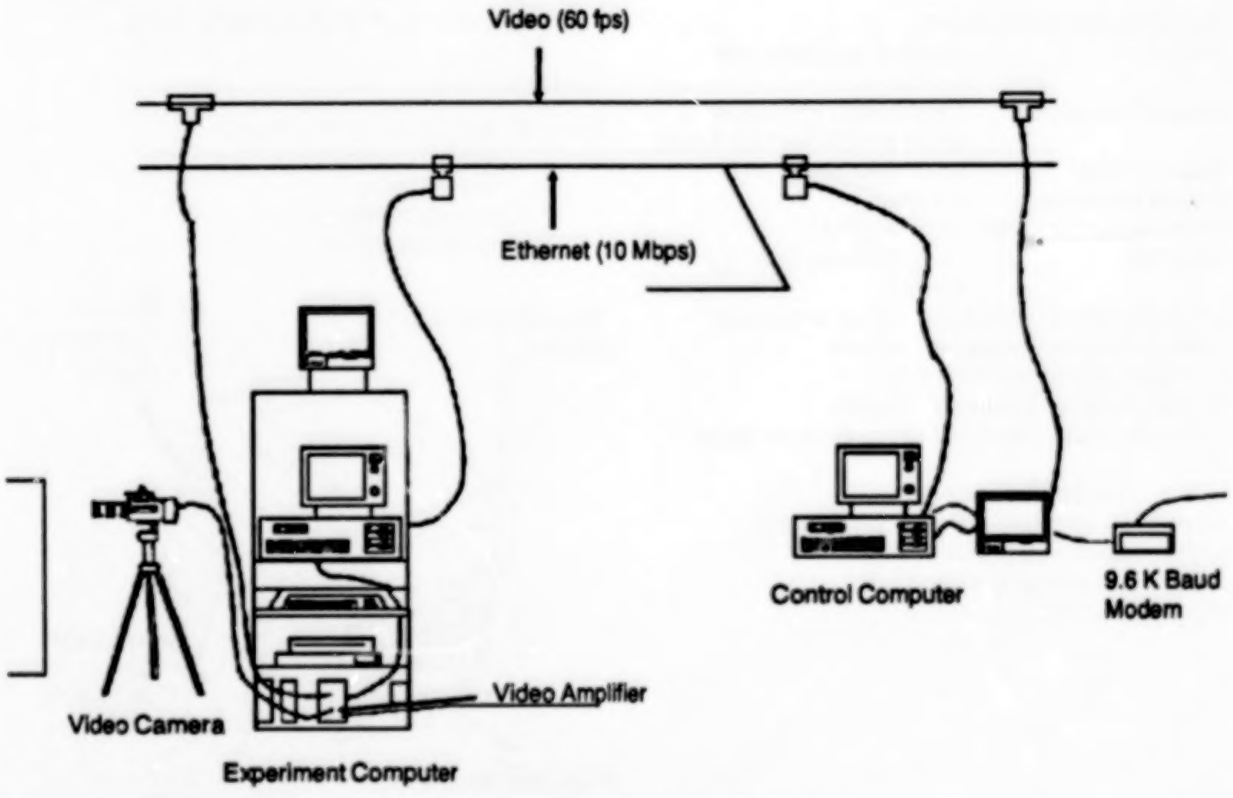
Communications
Ethernet
Video network cable
9600 baud modem

Miscellaneous Hardware
Remotely controllable microscope
Three axis positioner

Carrier: Designed for ground-based research only

Available: Now

Contact: Thomas K. Glasgow
Processing Science & Technology Branch
NASA/Lewis Research Center
21000 Brookpark Road MS 105-1
Cleveland, OH 44135
(216) 433-5014



μgNET MMSL Data/Video Network

Recorders

Digital Data Recorder

The Sony DIR-1000 Digital Data Recorder employs the technology of digital rotary head recording and enables high-density, high speed, recording and reproduction. The DIR-1000 can record up to approximately 100 GBytes (770 Gbits) of data on a large cassette tape (19mm width) at 32 MBytes/second. This corresponds to the storage capacity available on 500 magnetic tapes of the types commonly used for data storage at a recording rate of approximately ten times the speed of a MT drive. The DIR-1000 can operate with the small, medium and large D-1 cassette tapes commonly used by broadcasters. The maximum storage capacities available on small and medium cassettes are approximately 14 and 44 MBytes respectively. The DIR-1000 is designed to permit remote control and status monitor via RS-422, GPIB or RS-232C interfaces. The unit's built-in self-diagnostics makes it possible for the DIR-1000 to isolate problems and highlight which boards need replacing. The DIR-1000 conforms to the specifications of the ANSI (American National Standard Institute) ID-1 Format.

Available: Now

Contact: Data Recording Products
Sony Business and Professional Group
3 Paragon Drive
Montvale, NJ 07645
(201) 358-4213

Instrumentation Recorder

The Sony PC-108M Instrumentation Recorder employs Pulse Code Modulation (PCM) to provide high-fidelity recording. Designed to receive data from a variety of inputs, the PC-108M receives analog data signals from a range of sources such as process monitoring equipment and measurement devices. The unit's PCM system converts the analog signals which are recorded on tape. DAT technology enables high-definition recording on metal tape of 3.81 mm in width; the unit's error correction system corrects for random and burst error.

The PC-108M's 16-bit linear quantization ensures that the signal to noise ratio is radically improved by as much as 20 dB over conventional FM systems, thus permitting the unit to record signals that otherwise would remain inaccessible. Signals of discrete frequency ranges can be recorded simultaneously or reproduced by offering multiple band/channel modes from 2 channels x 20 kHz up to 8 channels x 5 kHz. The characteristics of the analog filter are improved and total phase difference is significantly reduced by incorporating 1/2 decimation digital filters in the recording block and double over-sampling filters in the reproduction block.

Separate control functions allow for self check, search, auto repeat and digital dubbing information to be displayed. In the self-check mode the PC-108M's key functions are examined for faults. The search function allows the user to access any part of the tape at up to 200-times playback speed by specifying a counter value, address, ID, time code or event marker on the LCD display. Digital-to-digital dubbing is possible with an optional digital dubbing cable.

Information may be recorded and reproduced simultaneously with the data, such as address, ID, memo, time code, event marker, start ID, voice memo, multiple B/C modes, attenuator and coupling. The PC-108M's design permits GP-IB control of the unit's functions from a personal computer while EXT control is available to govern the operation of the tape transport. An optional RM-108 remote control unit also can be used for these purposes.

Available: Now

Contact: Data Recording Products
Sony Business and Professional Group
3 Paragon Drive
Montvale, NJ 07645
(201) 358-4213

Ultra High Density Tape Recorder

This longitudinal magnetic tape recorder, developed for Very Long Baseline Interferometry, is capable of recording data at rates greater than one Gigabit per second and storing nearly one Terabyte of data on a single tape reel.

The Ultra High Density Digital Tape Recording System, Model DR-101A, may be configured with either software error correction for high-volume, low-data rate applications, or with hardware error correction for wide-bandwidth requirements. In the latter case, a configurable user-to-storage interface unit eliminates the usual magnetic tape difficulties associated with formatting, error correction, modulation, recording interface and user interface. A chief benefit to using the DR-101A is its extremely high volume bit density. Adopting such a system reduces the expense of maintaining archival records in usable condition. A Terabyte tape has a significant volume bit density advantage over other archive media, such as optical disks, and can be duplicated in less than an hour.

Operational Characteristics

Up to 1 Terabyte of data on one tape (8×10^{12} bits)
1 inch video or D1-type tape; reels to 16 in
Area bit density: 27 Mbit/square inch;
36 tracks per headstack;
up to 4 headstacks
Record rate: 315 Mbit/second unformatted
Modular expansion to 1300 Mbit/second
Selectable record and playback rates down to 4 Mbit/second
Honeywell Model 96 tape transport with special modifications to enhance tracking repeatability to 1 micron
Embedded VME microprocessor control of transport and piezoelectric head motion actuator
RS-232C communications interface with ASCII protocol
Head life typically 10,000 hours continuous operation at maximum record rate
MTBF 10,000 hours
Recording media costs $0.60 per Gigabyte

Available: Now

Contact: Dino A. Lorenzini, V.P., Operations
Interferometrics, Inc.
8150 Leesburg Pike, Suite 1400
Vienna, VA 22182-2799
(703) 790-8500, Fax (703) 848-2492

Satellites

Interferometric Satellite Tracking System

Designed to track NASA's TDRS satellites, this system includes the requisite hardware and software to track commercial satellites operating at Ku-Band, from 11.7 GHz-12.2 GHz. Completely passive techniques are employed and normal satellite signals are treated as noise by the correlation circuitry. The tracker is comprised of three remotely controlled field stations, which transmit data to the central processing site in Vienna, VA.

Operational Characteristics
Passively tracks satellites operating in either the TDRS (13.4 – 14.1 GHz) or Domsat (11.7 GHz – 12.2 GHz) bands
Absolute tracking accuracy is 20 meters
Interferometer consists of three 1.8 meter offset antennas mounted on polar mounts with both declination and hour angle remotely controllable
Dual-band linearly polarized front end
Each measurement site is remotely controllable from a central site

Carrier: Designed for ground-based operations

Available: Now

Contact: Dino A. Lorenzini, V.P., Operations
Interferometrics, Inc.
8150 Leesburg Pike, Suite 1400
Vienna, VA 22182-2799
(703) 790-8500, Fax (703) 848-2492

Satellite Master Ground Station

This Personnel Access Satellite Terminal is capable of communicating with Low Earth Orbit satellites. The battery-powered terminal can communicate with Interferometrics' Eyesat spacecraft and a number of other "Microsats" that operate in the UHF/VHF band.

Operational Characteristics

Portable unit:	Fits in a briefcase
Weight:	Approximately 25 lbs
Cost:	Less than $10,000
Operation:	Controlled by a personal computer
Power:	Less than 10-Watt transmitter
Setup:	Omni antenna; doppler corrected

Potential Applications
Dedicated data link between central site and worldwide field offices
Data relay from remote monitoring sites
Mobile Communications Terminal

Carrier: Designed for ground-based operation

Available: 6 Months after receipt of order

Contact: Dino A. Lorenzini, V.P., Operations
Interferometrics, Inc.
8150 Leesburg Pike, Suite 1400
Vienna, VA 22182-2799
(703) 790-8500, Fax (703) 848-2492

Miscellaneous Items

2 Axis Gimbal

This two axis gimbal is used to stabilize and steer an airborne telescope. The gimbal was designed and manufactured as part of a fast turn-around program.

Operational Characteristics

	Roll	Pitch
Rotation	+/-60 degrees	+/-41 degrees
Rate	110 deg/sec	90 deg/sec
Acceleration	400 deg/S2	400 deg/S2

Accuracy
7 Arc Minutes

Available: Now

Contact: Versatron Corporation
103 Plaza Street
Healdsburg, CA 95448
(707) 433-8244, Fax (707) 433-7110

2 Axis Gimballed Mirror

This two axis gimbal uses mirrors to direct a laser to scan for poison gases in the atmosphere.

Operational Characteristics

	Roll	Pitch
Rotation	+/-63 degrees	+/-16 degrees
Rate	100 deg/sec	80 deg/sec
Acceleration	600 deg/S2	2000 deg/S2

Accuracy
1 Arc Minute

Available: Now

Contact: Versatron Corporation
103 Plaza Street
Healdsburg, CA 95448
(707) 433-8244, Fax (707) 433-7110

2 Axis Optical Gimbal

This spaceborne optical gimbal is used with a laser radar system. It is both a transmitting and a receiving system. The system features space ruggedized electronics.

Operational Characteristics

	Roll	Pitch
Rotation	+/-2.5 degrees	+/-5.0 degrees
Rate	160 deg/sec	160 deg/sec
Acceleration	5500 deg/S2	5500 deg/S2

Accuracy
8 Arc seconds

Bandwidth
5Hz @ +/-5 degrees

Available: Now

Contact: Versatron Corporation
103 Plaza Street
Healdsburg, CA 95448
(707) 433-8244, Fax (707) 433-7110

Accelerometer Package

The function of the accelerometer package is to: measure low-g accelerations along three orthogonal axes; generate output signals proportional to these accelerations; provide 3 levels of g measurement- 1 x 10^{-2} , 1 x 10^{-4} and 1 x 10^{-6}; provide signals to the ground via telemetry and to on-board experiments when a specified low level of acceleration in all three directions is obtained; display the microgravity levels on the ground in real-time and; store the data both on-board and on the ground for later detailed analysis.

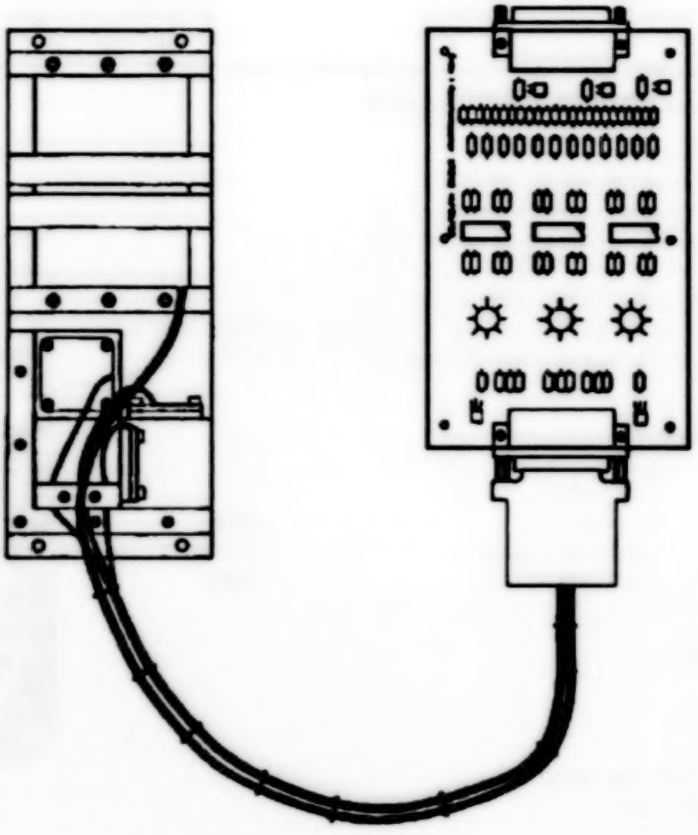
Contact: Jan Bijvoet
Consortium for Materials Development in Space
University of Alabama in Huntsville
Research Institute Building, Room M-65
Huntsville, AL 35899
(205) 895-6620

Operational Characteristics

Size:	216mm x 83mm x 95 mm and 107mm x 236mm x 24 mm
Weight:	1.5 kg
Power:	26-30 Vdc, 5.4 W power consumption

Carrier: Suborbital Rockets

Available: Now



Compact Smart Accelerometer

Small enough to be located with a broad range of microgravity experiments, this accelerometer has real-time, standard digital data output that can interface with any standard computer to provide useable data. Optional software features include frequency and power spectrum analysis, event detection, background measurement, averaging and immediate access to the data in flight or on Earth. The unit can be used for materials processing and life sciences experiments, on-orbit microgravity measurements, reentry acceleration measurements and vibration detection. May be customized to meet specific requirements.

Software options

- Coordinate transformation
- FFT spectral analysis of oscillatory disturbances
- Averaging program for steady state forces
- Event detection for transient acceleration
- Cataloguing of events

Operational Characteristics

Measurement	
Range:	10^{-6} to 10^{1} g
Resolution:	1 µg
Bandwidth:	10^{-5} - 10^{2} Hz
Physical Characteristics	
Mass:	<2 kg
Volume:	<.0015 cubic m (75 cubic in)
Maximum sampling rate:	800 Hz
Axis alignment:	within 2,000 urad
Supply voltage:	28 V
Power requirements:	15 W
Data:	RS-422 serial interface
Location:	Ground-based and on-orbit experiments

Available: Now

Contact: Michael D. Barg
Payload Systems Inc.
276 Third Street
Cambridge, MA 02142
(617) 868-8086, Fax (617) 868-6682

Dispenser for Carbonated Beverages

The space dispenser is designed to provide astronauts with carbonated beverages without foaming. It features a unique internal dispensing mechanism that compensates for zero-gravity. It has a drinking spout, a screw-on safety cap, a valve safety lock, a liquid flow adjustment screw, a cap retainer cord and a Velcro fastener strip. The dispenser is counter-pressurized to about 50 psig by carbon dioxide gas.

Operational Characteristics

Size:	5.75 in H x 2.5 in diameter
Full weight:	500 grams
Counter pressure:	50 psig
Pressure at nozzle:	Less than 1 psig
Flow rate:	5 ml per second
Power requirement:	None

Carrier: Shuttle middeck

Available: Now

Contact: A.S. Gupta
The Coca-Cola Company
P.O. Drawer 1734
Atlanta, GA 30301
(404) 676-4454

Division of Amplitude Polarimetric Pyrometer (DAPP)

The DAPP is a device for the measurement of surface emissivity and thermodynamic temperature of specular and partially specular surfaces. It employs laser reflection techniques based on the principles of polarized light reflection. The emissivities, indices of refraction and extinction coefficients are obtained at the laser wavelength. Concurrently, the spectral radiance of the surface is measured. The thermodynamic temperature is then determined to a high level of accuracy. The DAPP technology can be adapted to containerless processing systems for the highest accuracy temperature measurements.

This device employs a laser, operating at 0.6328 um, and can measure true surface temperatures in the range 1,000° to 2,500° K. The detection system consists of a special polarimeter capable of measuring all four Stokes vectors of reflected and emitted light instantaneously. The error in the emittance measurement is about 1%, the maximum error in temperature measurement is +5°K at 2,000°K. The temperature resolution is about 1°K at 1,000°K and the instrument response time is typically 0.1 second.

Operational Characteristics

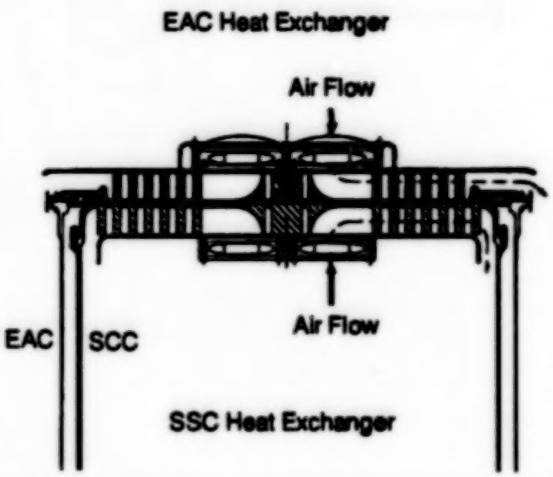
Operating temperature range:	1,000° to 2,500° K
Surfaces which can be analyzed:	Specular or partially Specular
Design Wavelength:	0.6328 um
Response time:	<100 milliseconds
Resolution:	1° K at 1,000° K
Error in emittance:	+/-1%
Error in true thermodynamic temperature:	<+/5° K at 2,000° K

Available: Under development

Contact: Shankar Krishnan
Intersonics, Inc.
3453 Commercial Avenue
Northbrook, IL 60062
(708) 272-1772

Experiment Apparatus Container (EAC) Heat Exchanger

The EAC heat exchanger is a heat removal system for the standard NASA Experiment Apparatus Container (EAC) and the 3M Second Containment Canister (SCC). The apparatus replaces the standard EAC and SCC covers and provides a fan-driven air-to-air heat exchange from the apparatus across two levels of hermetic containment to the cabin air. Examples of the temperature differential across the interface during continuous heat transfer are 9° C and 13° C at 150 Watts.



Operational Characteristics

Power:	14 W
Size:	11 cm thick
Weight:	adds 6 kg to cover weight

Carrier: Shuttle middeck or Spacelab

Available: Now

Contact: E. L. Cook
3M Space Research and Applications Laboratory, Bldg. 201-2N-19
3M Center
St. Paul, MN 55144
(612) 733-4357

Honeywell In-Space Accelerometer (HISA)

The HG1120AA Honeywell In-Space Accelerometer (HISA) is a three-axis microgravity accelerometer instrument developed to monitor oscillatory and transient accelerations onboard spacecraft. The HISA is designed to be co-located with materials processing equipment to continuously record accelerometer event data, sampling time and temperature. A space-qualified version of the HISA has flown on previous Shuttle missions.

Features
Force rebalance accelerometers (3)
Internal temperature sensors for thermal compensation
Low-power, 8 bit measurement and control computer
Resolution less than 1 micro-g
Delta velocity digitization
Zero DC bias effect
Small size (64 in^3)
Three-pole roll-off filter response
Internal power supply (+28V required)
ASCII communications format

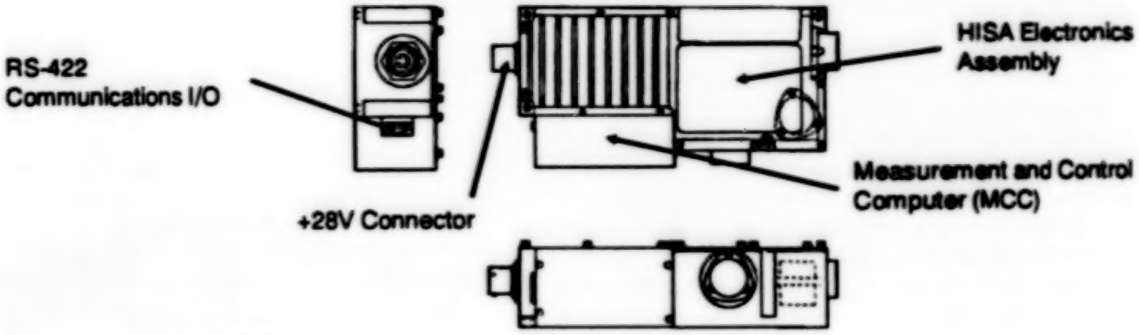
Operational Characteristics

Orientation:	Three-axis orthogonal
Range:	10^{-6} to 10^{-2} g (increments of 1.0×10^{-6} power g) at 1 Hz; 10^{-5} to 10^{-2} g (increments of 9.0 to ten^{-6} g) at 50 Hz
Accuracy:	+/-(1%[reading] + 0.00002) g
Resolution:	<1.0 micro-g at 1 Hz 8.7 micro-g at 50 Hz
Frequency Response (+/-5%):	0.025 to 19.500 Hz
DC Bias:	None (AC output)
Sample Data Rate:	50 Hz, 1 Hz
Communications:	RS-422/ASCII format
Size:	8.0 in x 3.8 in x 2.1 in. (64 cubic in.)
Weight:	4.0 lb
Power:	5.6 W (@ 28V)

Carrier: Various locations on the Shuttle

Available: Now

Contact: Jeff Schoess
Honeywell Corporation
3660 Technology Drive
Minneapolis, MN 55418
(612) 782-7359



Infrared Scanning Pyrometer

As presently configured, this instrument measures surface temperatures above 200° C by means of calibrated IR (5um) measurements. An electromagnetically driven mirror permits repetitive, selectable linear scans across sample surfaces. Designed for use in furnaces using quartz-halogen heating lamps, the pyrometer has been flight tested in microgravity conditions.

Carrier: Shuttle middeck

Available: Under development

Contact: Walter H. Wurster
Calspan Corporation
Advanced Technology Center
P.O. Box 400
Buffalo, NY 14225
(716) 631-6846

IONGUARD

IONGUARD signifies a series of ion implantation processes designed specifically for the needs of the aerospace industry. It is a process by which a precise quantity of atoms of a desired element can be physically injected into the surface of a material. The result is that the corrosion, oxidation, wear and friction performance all are improved. This is accomplished without any change in product color or dimension.

The IONGUARD process is used on finished products and is ready for use immediately after treatment. The ion implantation process will not change any of the bulk properties but is a unique method by which the user can alter the surface properties of a material to meet tribiological and chemical requirements.

Products employing the IONGUARD process include bearings for the Shuttle main engine, various types of radial and 4-point radial arch bearings used in satellites, landing gear materials, cryogenic bearings and components. Materials which have been treated include, 440C stainless steel, 52100 titanium, aluminum, as well as a host of other materials. Products may range in size from 0.1 inch diameter up to 36 inch diameter.

Available: Now

Contact: Spire Corporation
Patriots Park
Bedford, MA 01730
(617) 275-6000

Laser Light Scattering Instrument

This instrument allows characterization of particles in the range of 3 nanometer to above 3 microns. Dynamic light scattering probes mean size distributions, transport coefficients and interactions in colloidal dispersions. Classical light scattering can provide information on the structure and orientation of macromolecules in suspension.

Operational Characteristics
Light Source Modules
Solid state and semiconductor lasers (multiple laser option)

Power output:	>20 m Watts
Beam size dictated by laser:	approx. 1.53 mm diameter
Laser Linewidth:	<80 MHz

Mode Output Single, TEM_{oo}
Zero mode hopping after warm-up
Excess Auto-correlations <0.04%

Coherence length:	>3.75 meters
Polarization:	500:1 if possible

Detector Modules
Avalanche photodiodes suitable for both dynamic and static laser light scattering.

Dark count rate:	<300 cts/sec
Dead time:	(<20 ns)
Count rate stability:	<+/-1/2% over experimental time
Quantum efficiency:	>25%
Count rate linearity up to	10 MHz
Afterpulsing:	<0.04%

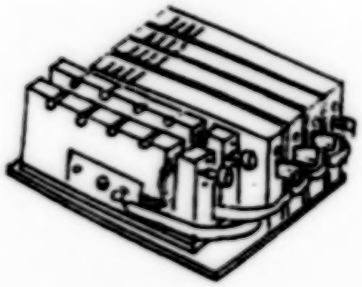
Power consumption <6 Watts
Anti-lock-up after saturation

Sample Cells: Interchangeable-Single or multiangle; Peltier temperature control; Fiber optic probe connections

Carrier: Shuttle and Space Station

Available: Under development

Contact: W. Meyer, R. Ansari
NASA/Lewis Research Center, MS 105-1
Microgravity Materials Science Laboratory
Cleveland, OH 44135
(216) 433-5011



Lasers and Detectors

Nearfield Antenna Measurement System

The NSI 200 series of portable Nearfield Antenna Measurement Systems provides complete antenna performance measurements of medium and high-gain microwave antennas even while the antenna is attached to a spacecraft. Typical applications include flight qualification tests and antenna/spacecraft interaction tests with operating frequencies between 1 and 100 GHz. The systems are portable, easily shipped across country and readily setup and used in a spacecraft high bay area.

The Nearfield Measurement System consists of a microwave probe, scanning mechanism, network analyzer and an IBM PC-based computer. Zero G antenna performance measurements are simplified, as no motion of the antenna or vehicle is required. The equivalent farfield antenna performance is derived from the measured electromagnetic Nearfield and a Fourier transform process. Additional holographic processing can be used to create images of antenna distortions.

Available: Now

Contact: Dan Slater
Nearfield Systems, Inc.
1330 East 223 RD ST No. 524
Carson, CA 90745
(213) 518-4277

Radiative Cooler

A radiative cooler cools detectors, such as infra-red or gamma ray detectors, by rejecting thermal energy to deep space. Temperatures in the 85° K to 110° K range can be achieved with detector thermal loads ranging from 10 to 40 mw. These devices require no electric power from the spacecraft except for monitoring instrumentation. They do require, however, a clear field of view ranging upward from a 100 degree solid cone. For best results, the clear field of view should be totally free of any warm object, such as an antenna, solar panel or the Earth. Precise optical alignment can be maintained. More than 30 coolers have been produced for Air Force and NASA instruments and when deployed have functioned in orbit.

Operational Characteristics

Weight:	3 to 15 pounds, depending upon size
Size:	12 in diameter x 7 in long-to-18 in diameter x 8 in L

Materials typically used in construction: aluminum, magnesium, stainless steel

Carrier: On-orbit spacecraft

Available: Now. If an existing design can be used, construction time is about 8 months. A new design generally requires at least one year for delivery.

Contact: Art Post
Arthur D. Little, Inc.
20 Acorn Park
Cambridge, MA 02140
(800) 677-3000

Self-Luminous Materials

Encapsulating phosphor particles and tritium gas within glass microspheres makes possible the production of a self-luminous paint. Once the active elements have been encapsulated, the microspheres can be mixed in a clear resin, silicone or similar binder to produce a long-lasting paint. The tritium-phosphor microspheres require no electrical connections or external power, do not consume oxygen or evolve soot or fumes. Potential applications in space are vehicle identification, interior capsule lighting for both instrument panel and exterior wall surfaces.

Operational Characteristics

Particle size:	0.1 mm (approximate)
Maximum intensity:	Visible Light
Color:	Green/yellow (other choices possible), 530 to 570 Nanometers
Physical Properties:	Bulk Density: 1.6 to 1.9 g/cc
Operational Temperature Range:	-30° to +120° C
Operational Pressure:	6.9 MPa (1000 psi)

Chemically Inert (the only external surface is Borasilicate Glass)

Safety: The tritium/phosphor u-sphere, as a system, is intrinsically safe. The glass is inert. The phosphor is similar to that used in fluorescent lights and TV picture tubes, requiring no special considerations. Because the u-sphere is so small it contains a minuscule amount of tritium, approximately 134 x 10^{-9} cc.

Available: Under development

Contact: Omtek Inc.
3722 Calle Cita
Santa Barbara, CA 93105
(805) 687-9629

Signal Conditioner

ELDEC Dedicated Signal Conditioner (DSC) provides signal conditioning and sensor excitation power supply for operational sensors. The modular design is available in 15, 20 and 30 module enclosures. Each module has four channels of signal conditioning/excitation.

A full range of modules are available including:

- Pulse rate to DC converter
- Resistance to DC converter (linear)
- Resistance to DC converter (non-linear)
- AC to DC converter
- AC level to logic level converter
- 5V logic level and switch closure detector/isolator
- DC Instrumentation amplifier/exciter with integral sensor excitation

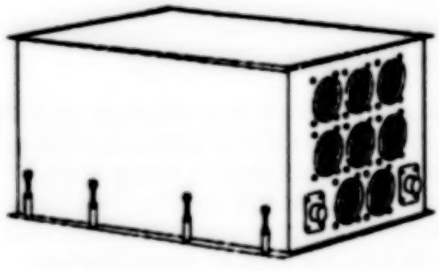
Operational Characteristics

Modules	15	20	30
Dimensions L (in)	10.1	11.8	15.8
Dimensions W (in)	7.9	7.9	7.9
Dimensions H (in)	7.0	7.0	7.0
Cooling:	Not required		
Environmental Operating Temperature:	-55° C to +93° C		

Carrier: Shuttle cargo bay

Available: Now

Contact: ELDEC Corporation
Monitor and Control Division
16700 13th Avenue West
Lynnwoood, WA 98037-8503
(206) 743-1313



Solar Cell Coverglasses

Coverglasses are used to protect solar cell arrays from ultra-violet, electron and proton irradiation damage. Pilkington Space Technology Coverglasses are manufactured from ultra thin cerium-doped glass.

The following table summarizes solar cell coverglasses available from Pilkington:

Glass Type	Bonding Suitability	Qualification Status
CMX Industry Standard	Conventional Silicone Adhesives	Space-Qualified
CMZ Thermal Expansion matched to silicon	Conventional Adhesives Teflon Bonding to Silicon Electrostatic Bonding to Silicon	Space-Qualified
CMG Thermal Expansion matched to Gallium Arsenide	Conventional Adhesives Teflon Bonding to GaAs Electrostatic Bonding to GaAs	In Qualification

All glass types contain a nominal 5% cerium dioxide for radiation stability and ultraviolet absorption. Available in sizes from 5 x 5 mm up to 100 x 100 mm as standard.
Compatible with PST coverglass coatings and available in a range of thicknesses from 0.050 mm (2 mils) to 0.500 mm (20 mils) as standard. Other thicknesses upon request. Strength can be enhanced for better handling.

Available: Now

Contact: Terence S. Griffiths
Business Development Director
Pilkington Optronics, Inc.
7550 Chaponan Avenue
Garden Grove, CA 92641
(714) 373-6061

Space Acceleration Measurement System (SAMS)

The SAMS can measure, condition and record low-g accelerations of the microgravity environment experienced by Shuttle experiments.

Available: Now

Contact: NASA/Lewis Research Center
Microgravity Materials Science Laboratory
Cleveland, OH 44135
(216) 422-5285

Space Structure Coatings

The industrial process of chemical vapor deposition is a cost-effective method of protecting graphite-epoxy composites from the degrading effects of atomic oxygen and ultraviolet light in orbit. The process provides low temperature metal coatings applied to composite and other material space structures.

Inflatable structures in space can be coated by a gas containing a metal species. Upon contact with the heated inner wall of the structure, the gas decomposes and deposits a metal film, making the inflated structure rigid. The coatings of aluminum and steel alloys can be applied on various shapes and sizes of components on Earth, or the systems can be deployed on spacecrafts.

Available: Now

Contact: Richard Westfall
President and Director of Research
Galactic Mining Industries, Inc.
4838 Stuart St.
Denver, CO 80212-2933,
(303) 433-5935

Temperature Sensor, Platinum Resistance

Model 118MF is a general purpose sensor designed to measure temperature over the range -260° C to +400° C. The sensing element is made of pure platinum wire mounted in ceramic insulation to ensure stain-free operation. It may be mounted by cementing or clamping in place.

Model 118MF is available with ice-point resistances varying from 100 to 2000 ohms in 100 ohm increments. Unless otherwise specified, the ice-point resistance tolerance shall be +/-2.0%. Unless otherwise specified, each sensor is calibrated at the ice point (0° C) accurate to +/-0.04° C. Additional calibration at -268.95° C, -195.87° C, -182.97° C, 100° C and 260° C is available. All calibration is traceable to the National Institute of Standards and Technology.

This sensor can withstand 20 consecutive temperature shocks from liquid nitrogen to room temperature trichlorethylene after which calibration at 0° C changes no more than +/-0.1° C. The insulation resistance between any sensor lead and the plate exceeds 10 megohms with 100 volts DC applied.

The time required for 63.2 percent response of an unmounted sensor, to a step change in temperature from room temperature air to #200 Dow Corning 1.5 CTSK oil flowing transverse to the sensing surface at 3 fps and at 76+/-4° C is less than 0.5 seconds. This response time is given because it represents a convenient reproducible laboratory condition. The in service response of the unit will depend upon how it is mounted and the environment in which it is used.

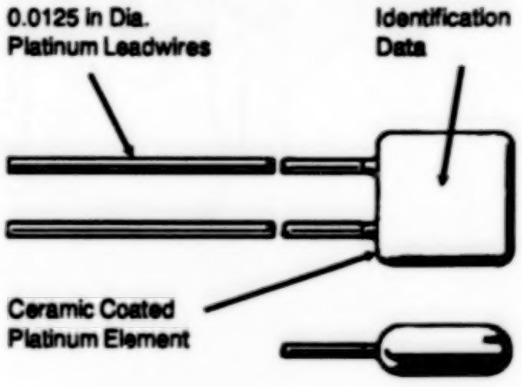
An unmounted sensor is capable of dissipating an I2R power of 46 milliwatts with a temperature rise of less than 1° C when submerged in #200 Dow Corning 1.5 CTSK oil flowing transverse to the sensing surface at 3 fps and at 25+/-5° C.

When the sensor and leads are firmly attached to a surface, the sensor withstands at least 80 g's peak or 0.5 inch double amplitude in any axis when cycled from 20 to 2000 Hz over a 15-minute time interval.

Model 118MF is suitable for use in any fluid or environment that is compatible with platinum and a ceramic composed of metal oxides. It is not susceptible to moisture absorption in moderate humidity atmospheres if the leads are suitably protected.

Available: The sensor is available in two, three or four lead wire configurations

Contact: Paul Bayer, Marketing Engineer
Temperature Group
Rosemount Inc., Aerospace Division
1256 Trapp Road
Eagan, MN 55121
(612) 681-8977, Fax (612) 681-8991



Time-Temperature Monitor

Time-temperature monitors measure and record fluctuation in temperature that occurs during transportation or storage of temperature-sensitive products. Temperature changes are sensed by a temperature-reactive element. Readings are registered either in digital form that can be downloaded into a computer, or directly on a paper chart.

Ryan TempMentor measures temperature variations in experiments in macromolecular crystallography. The TempMentor makes temperature measurements at 16 sampling rates from 1 per second to once every 2 hours, with maximum deployment of 530 days. Logs up to 6,361 temperature measurements.

Several types of temperature monitors are available.

Operational Characteristics
Range: -32° C to + 70° C

Available: Now

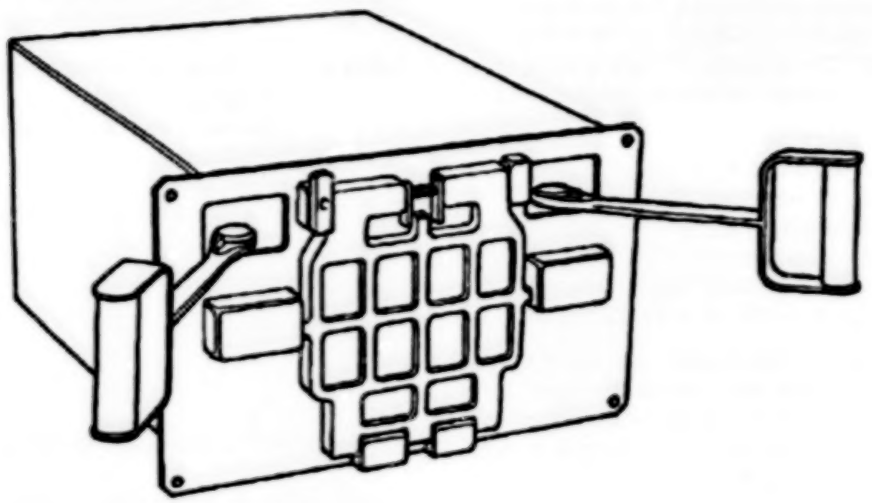
Contact: Ryan Instruments
8801 148th Avenue, NE
P.O. Box 599
Redmond, WA 98073-0599
(800) 999-7926

TRASHMASHER

TRASHMASHER is a manually-operated trash compactor that is self-contained and requires no power or hookups. It compacts trash in a specially developed wet trash bag to 25 percent of the original volume of the trash. Wet trash bags are provided to contain the trash, liquids, odors and biologically active substances in all gravity fields. TRASHMASHER was developed for use in the middeck of the Shuttle. It occupies the same volume and weight as a standard stowage locker, and is mounted the same way as a locker.

Available: Now

Contact: Johnson Engineering Corporation
3055 Center Green Drive
Boulder, CO 80301-5406
(303) 449-8152



Section Four: Experiment Carriers

To launch an experiment in space using an expendable launch vehicle or the Shuttle, the commercial developer must design the experiment, develop or select equipment to contain/operate the experiment and then integrate the package with an appropriate carrier. Carriers range from the no-frills class, such as the Get-Away-Special (GAS) canisters, to a middeck locker or the SPACEHAB module, to the full-service accommodations of Spacelab. Some carriers, such as SPACEHAB, are pressurized. Other carriers are not.

Most experiment carriers and support structures are developed for use in the middeck and cargo bay areas of the Shuttle. However, some carriers are adaptable for use on expendable launch vehicles or sounding rockets and can offer alternatives to the Shuttle. Several advantages and operational restrictions are unique to each situation and, therefore, influence experiment design, choice of carrier and the means of interfacing experiment hardware to the host facility. For example, Shuttle middeck payloads are carried in one or more middeck storage lockers and may have crew involvement. Carriers having manned or man-tended environments are so noted. Many payloads use carriers that are self-contained and operate independently of the Shuttle's resources, while others draw upon these resources for power, data gathering, etc. Each entry in this section offers operational characteristics for each carrier, assembly or rack, indicating specifications and location possibilities.

The Shuttle middeck is a confined space located directly below the flight deck and adjacent to the cargo bay. Resources available on the middeck are limited in both power and heat-rejection capability. The standard power available is 28 volts DC, 115 Watts. While space also is limited, advantages of experimentation on the middeck include potential for more frequent flight opportunities; reduced payload integration time and cost; late access to and early recovery of the experiment package; and crew interaction with the experiment, if required.

Greater power and heat-rejection capabilities are available to an experiment located in the cargo (or payload) bay than in the middeck, and larger experiments can be accommodated. Integration time and cost may increase when using large carriers; however, the cargo bay also has provisions for small, self-contained payloads that can be integrated and assembled with other, similar payloads, on a carrier such as the Multi-Purpose Experiment Support Structure (MPESS).

With the exception of research conducted in the Spacelab carrier, all experiments in the cargo bay area are activated remotely by the crew from the Aft Flight Deck or operated from the ground. The Spacelab carrier,

however, offers a shirt-sleeve environment in which the crew can participate in experiments requiring real-time analysis and process modification. These crew-interactive experiments are housed in modular units designed to fit in standard Spacelab racks. At present, most accommodations in the Spacelab are committed through 1992. As a result, commercial researchers interested in using the Spacelab must consider scheduling far in advance.

Chapter 11: Manned/Man-Tended Environment Carriers

Experiments requiring operation, interaction or observation are considered manned or man-tended payloads, depending on the requirements and accommodations. In some cases, the astronaut merely switches on-off levers to initiate or terminate a process. In other cases, however, the astronaut may conduct research by manipulating equipment, testing samples or creating effects.

This chapter features equipment that supports manned and man-tended experiments that fly on the Shuttle, or as freeflyers, satellites or platforms. Each of these carriers offers variable accommodations such as volume, weight, power, cooling, etc.

Experiment Support Platform (ESP)

The ESP is a lined-sized aluminum sheet container designed to support flight experiments within the Shuttle middeck locker. The interior is fitted with mounting bars tapped for 4-40 screws on 1-inch centers for attachment of experimental apparatus. Available mounting fixtures include several configurations of slotted-angle and channel, a 1/4-20 tapped optical bench and a similarly tapped 1/8-inch floor plate. The unit is fitted with fans mounted in the side tubes to allow movement of cooling air through the system. For shipping or storage, the ESP may be collapsed into component identical side tubes, top and bottom covers, and front and back plates. Attachment is by 1/4-turn fasteners. A number of interior and exterior cover plates may be fabricated to order. A matching set of locker-modified door panels has been fabricated and is available to accommodate the air handling and power interfacing needs of the unit.

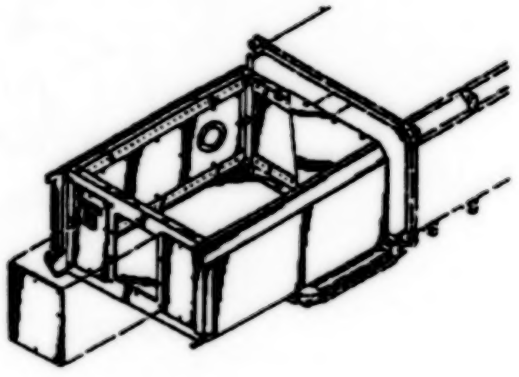
Operational Characteristics

Dimensions:		9.7 in x 17 in x 20 in dimensions of Shuttle middeck locker liner – 1/2 or full locker sizes
Volume:	full locker	approximately 2 ft^2 or
	1/2 locker	1 ft^2
Weight:	full locker	11 lbs or
	1/2 locker	9 lbs without fans and mounting fixtures
Power:		Experiment specific, connector to front panel through a standard 12-pin Shuttle connector
Cooling:		By fans located in the side tube

Location: Shuttle middeck locker

Available: Now

Contact: H. W. Scheld, Director of Research
PhytoResource Research, Inc.
707 Texas Ave., Suite 101-E
College Station, TX 77840
(409) 693-8606, Fax (409) 696-3451



Industrial Space Facility (ISF)

The Industrial Space Facility (ISF) is a man-tended freeflyer facility. Eventually, the ISF is expected to be a co-orbiting facility with the NASA Space Station. It is designed to provide basic utilities, primary power, cooling, communications and vacuum/venting to its users and other attached facilities requiring a power source. The facility is intended to serve as a microgravity research laboratory and, ultimately, as a materials processing facility. It also is suitable for a variety of other purposes such as storage, test bed, assembly platform and accommodation of attached payloads. The ISF will be man-tended and will provide a pressurized environment for equipment servicing and resupply in a "shirt-sleeve" manner, when docked with the Shuttle. The ISF will operate in a fully-automated mode between Shuttle servicings.

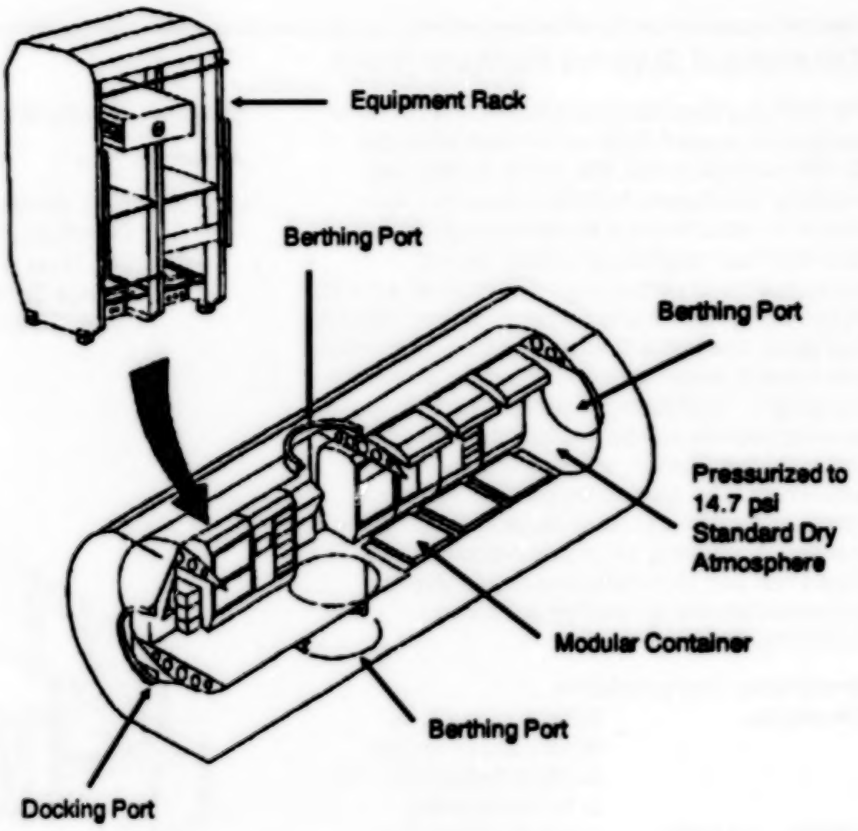
Operational Characteristics

Dimensions:	35.0 ft L x 9.5 ft diameter
Volume:	332 ft^3
Weight:	6,500 to 13,500 lbs
Power:	11 kW
Cooling:	11.0 kW L, 5.0 kW A
CMD & TLM:	2 kbs, 50 kbs

Carrier: Shuttle

Available: Under development

Contact: Space Industries, Inc.
711 W. Bay Area Blvd., Suite 320
Webster, TX 77598-4001
(713) 338-2676



Lower Rack Stowage Drawers

The stowage drawers are similar to the stowage trays. They have the same exterior front panel and may have similar interior restraint mechanisms. However, they have inner slides attached to the sides which are inserted into outer slides, attached to the interior of the rack. The inner slides have a snap lock which holds the drawers in place when they are pulled out a maximum of 22 inches from the front panel of the rack. The snap lock may be depressed to remove the drawer from the rack; however, this is not usual during normal usage.

The stowage drawer has standard dimensions for width and depth, which are approximately 16 inches and 24 inches, respectively. The height of the drawers varies with the number of front panel units (1.75 inches) required.

Available sizes:

7 panel units:	11.66 inches
6 panel units:	9.91 inches
5 panel units:	8.16 inches
4 panel units:	6.41 inches
3 panel units:	4.66 inches

Carrier: Shuttle middeck

Available: Now

Contact: NASA/Johnson Space Center
Life Sciences Experiments Program
Houston TX 77058
(713) 483-7328

Middeck Accommodations Rack (MAR)

The MAR increases the space available for small payloads and experiments in the Shuttle middeck by supplementing the volume occupied by middeck stowage lockers. The MAR is designed as a versatile experiment integration facility with the equivalent volume of five middeck lockers. Standard middeck trays or payloads specially sized to the MAR's capacity can be integrated in the carrier. Power distribution and active thermal control options are available.

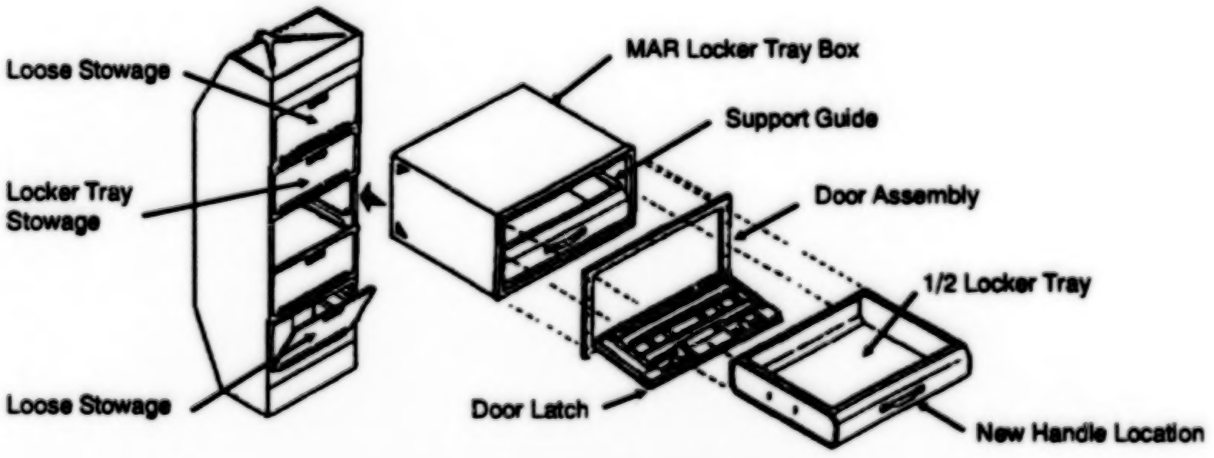
Operational Characteristics

Dimensions:	76 in H x 21 in W x 18 in D
Volume:	17 ft^3
Weight:	500 lbs including carrier (about 150 lbs)
Power:	1 kw (dc plus ac)
Cooling:	2 kW Liquid, 1 kW Air
CMD & TLM:	None, None

Location: Shuttle middeck

Available: Under development

Contact: NASA/Johnson Space Center
Customer Integration Office, Code TC4
Houston, TX 77058



MAR Locker Trays Installation

Middeck Experiment Apparatus Container (MD EAC)

EACs are convenient, economical devices that provide protective housing for experiment apparatus. Middeck EACs may be cylindrical or rectangular and contain experiments that weigh less and have lower power requirements than EAC experiments in the Shuttle cargo bay. Because middeck EACs offer an enclosed and sealed environment, certain safety waivers may be granted to the materials of components enclosed.

Four kinds of middeck EACs are available. Two are removable, cylindrical housings that can accommodate a variety of experiment apparatus. These have two sections: a cylindrical base on which the experiment is mounted and a taller component that encloses the experiment. One cylindrical EAC has a dome top, the other has a flat lid. A third middeck EAC is rectangular and provides a more rigid housing for experiment apparatus than either of the cylindrical containers. The fourth middeck EAC also is rectangular and provides accommodations for experiment electronics. Middeck EACs are designed for spaces normally occupied by middeck stowage lockers.

Operational Characteristics

Dimensions:	14.45 in H x 16.6 in diameter
Volume:	1.8 ft^3
Weight:	TBD
Power:	0.27 kW
Cooling:	0 kW Liquid, 0 kW Air
CMD & TLM:	TBD, TBD

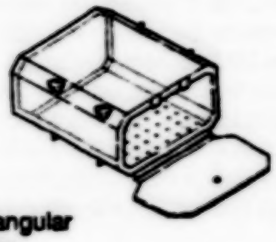
Location: Shuttle Middeck, SPACEHAB

Available: Now

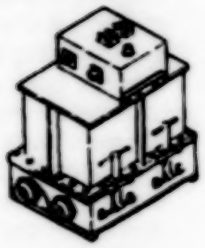
Contact: NASA/Marshall Space Flight Center
Microgravity Projects, Code JA81
Marshall Space Flight Center, AL 35812

Flat Top Cylindrical EAC

Dome Top Cylindrical EAC



Rectangular Locker Type EAC



Experiment Electronic Package

Middeck Locker (MDL)

The primary purpose of modular stowage lockers is to store crew food, clothing and payload support equipment. However, unused lockers may be made available for small, low-power experiments on a mission-by-mission basis. There are typically 13 MDLs located in the Shuttle middeck area which can be used with or without full or half-locker storage tray inserts. A double stowage locker also is available. Experiments contained in these lockers may be operated or observed by crew members.

If a larger space in the middeck is required, one or more modular stowage lockers may be removed and replaced by single or double adapter plates. These plates allow the direct mounting of experiment apparatus that are contained in appropriate hardware, e.g., an Experiment Apparatus Container. These adapter plates, along with modified locker doors, power cables and connectors, are provided by NASA as a part of the middeck payload accommodations.

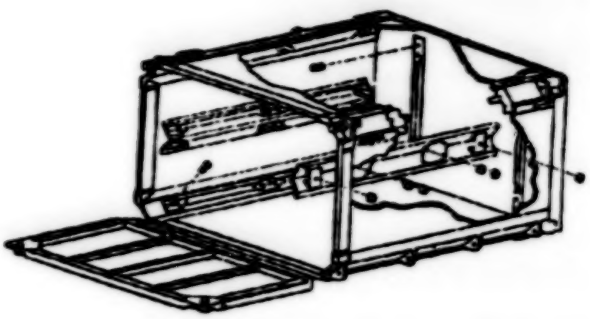
Operational Characteristics

Dimensions:	10.0 in H x 17.2 in W x 20.0 in D
Volume:	2.0 ft^3
Weight:	60.0 lbs
Power:	1 kW (total middeck)
Cooling:	0 kW Liquid, 1 kW Air (total middeck)
CMD & TLM:	N, N

Location: Spacelab, Shuttle Middeck, SMIDEX

Available: Now

Contact: NASA/Johnson Space Center
Customer Integration Office, Code TC4
Houston, TX 77058



Modular Container (MC)

The Modular Container, designed for the Industrial Space Facility (ISF) (see page 142), will have a capacity of 4 Shuttle middeck locker trays in a 2x2 configuration. The ISF can contain up to 6 modular containers in the Facility Module configuration.

Operational Characteristics

Dimensions:	12.0 in H x 36.0 in W x 40.0 in D
Volume:	11.0 ft^3
Weight:	375 lbs (payload capacity)
Power:	0.8 kW
Cooling:	0 kW Liquid 1.5 kW Air
CMD & TLM:	2 kbs, 50 kbs

Location: Industrial Space Facility (on orbit)

Available: Under development

Contact: Space Industries, Inc.
711 W. Bay Area Blvd., Suite 320
Webster, TX 77598-4001
(713) 338-2676

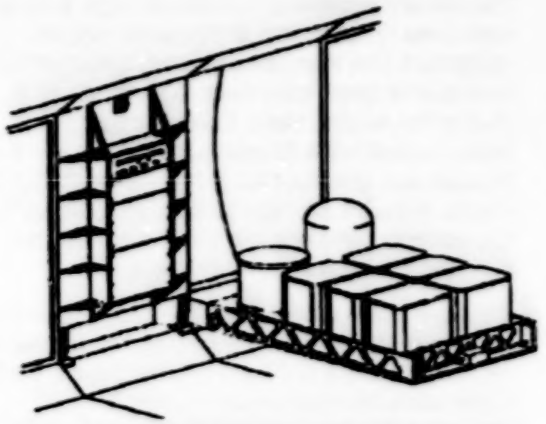
"Quick is Beautiful" Facility (QIB Facility)

The QIB facility is a multipurpose, small payload carrier that will provide easy access to space for small- to medium-sized microgravity research projects allowing proof-of-concept type investigations. Access to host resources (Shuttle or Space Station) is provided to experimenter/payloads through designed-in interfaces of the QIB facility. Examples of these resources are electrical power, air and water cooling, data, command and control, vacuum/vent, source gases, ultra-pure water and other special resources/consumables.

Location: Shuttle, Space Station

Available: Under development

Contact: Wyle Laboratories
7800 Governor Drive W.
Huntsville, AL 35807
(202) 837-4411



One of the QIB Facility Concepts Shown in the Space Station Laboratory Module

Shuttle Middeck

The middeck contains mounting space for 42 lockers, some of which are available for commercial payloads.

Equipment available for use in the middeck include modular stowage lockers, Experiment Apparatus Containers (EACs), the Middeck Accommodations Rack (MAR) and the Refrigerator/Incubator Module (R/IM). The Space Acceleration Measurement System (SAMS) also may be available to investigators using middeck facilities.

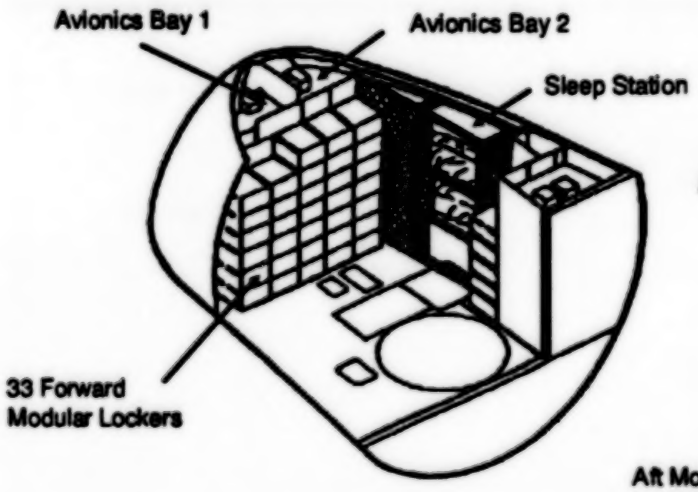
Operational Characteristics

Power:	0.6 to 0.9 kW each
Cooling:	0 L, 1 kW A
CMD & TLM:	N, N

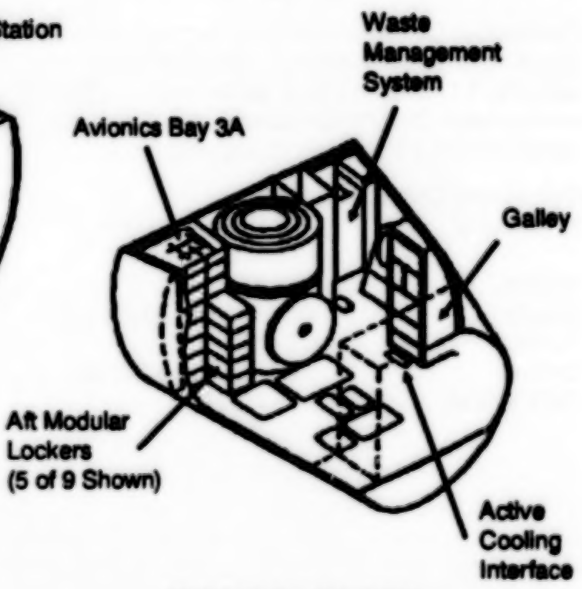
Location: Shuttle

Available: Now

Contact: NASA/Johnson Space Center
Customer Integration Office, Code TC4
Houston, TX 77058



Middeck (Looking Forward)



Middeck (Looking Aft)

Space Station Freedom

Space Station Freedom will be a permanently manned multi-purpose facility for science and applications programs. Now scheduled for completion in the late 1990s, the Station is a joint project of the United States, Canada, Japan and the nations of the European Space Agency. When the Station is completely assembled and operational, a broad spectrum of research in all the disciplines of life sciences, materials sciences, astrophysics, planetary sciences, Earth observation, commercial applications, etc. will be conducted. These activities will be accomplished with both manned and unmanned elements.

Plans for the Station presently feature four large pressurized modules clustered at the center of a trusswork boom, with two pairs of rectangular solar arrays attached to each end to supply electrical energy. Experiments, equipment and robotic arms for handling payloads can be attached to the boom and freeflying, instrumented platforms may add additional capabilities. These facilities, offering weightless periods measured in months and years rather than hours, minutes and seconds, will create new and greater opportunities for extended microgravity research.

One of the modules will serve as a habitation area and include a galley and sleeping quarters and other facilities where residents will live and relax. The others will serve as laboratories, where crew members can work in a shirt-sleeve environment, exploring the basic laws of physics that govern the delicate interaction between gravity, humans and materials.

The U.S. laboratory is designed to handle projects that need a stable microgravity environment for materials research as well as R&D in basic physics, chemistry and biology. The European and Japanese modules are designed primarily for research in fluid physics, life sciences and materials processing. Another component of the station will be the Canadian Mobile Servicing Center.

The Station will be located approximately 200 miles from Earth in a low-inclination orbit of 28.5 degrees to the equator. It will be built, serviced and supplied by the Shuttle, which also will ferry passengers up to and down from the orbiting base. Users will include any individuals, groups or agencies responsible for the development or operation of a payload, experiment, instrument or mission utilizing a component of the program.

The value of the Station is its utility for the 21st century; state-of-the-art research will create technological breakthroughs that will benefit people worldwide. While some of these benefits may become apparent during the first year of operation in orbit, many technology spinoffs may take as long as a decade to make the technology transfer and influence our daily lives. Space Station Freedom promises to be a major stimulation force for American industry. In addition, it ultimately will serve as a way station for space-bound missions, such as to the Moon and Mars.

Location: On orbit

Available: Late 1990s

Contact: Ken Taylor
Mail Code PS05
NASA/Marshall Space Flight Center
Huntsville, AL 35812
(205) 544-0640

SPACEHAB

SPACEHAB is a commercially-developed middeck augmentation module which expands the pressurized volume of the Shuttle and provides increased opportunity for astronaut-tended research and development. Two SPACEHAB flight modules are in production. Eight flights are scheduled under a Space Systems Development Agreement (SSDA) with NASA, with the first mission targeted for September 1992. SPACEHAB is mounted in the forward quarter of the Shuttle cargo bay and remains attached throughout the flight, connected to the middeck by a short tunnel.

The SPACEHAB module may be outfitted with up to 71 middeck-type lockers, identical in dimension and volume to those in the Shuttle middeck, or a combination of lockers and SPACEHAB-designed experiment racks. The racks are intended to be similar to those planned for Space Station. User-provided experiment support payload capacity in the forward bay position is 3000 pounds. Access to SPACEHAB module volume and associated services is commercially available to space experimenters worldwide through SPACEHAB, Inc.

Operational Characteristics

Dimensions

Module:	10.0 ft L x 13.5 ft diameter
Rack:	35.0 in L x 41.5 in W x 89.4 in H
Locker:	21.1 in L x 18.4 in W x 10.6 in H

Volume

Module:	1100 ft^3
Rack:	45.0 ft^3 payload
Locker:	2.0 ft^3 payload

Weight

Module:	9,200 lb (3,000 lb payload)
Rack:	1,400 lb (1,250 lb payload)
Locker:	78 lb (60 lb payload)

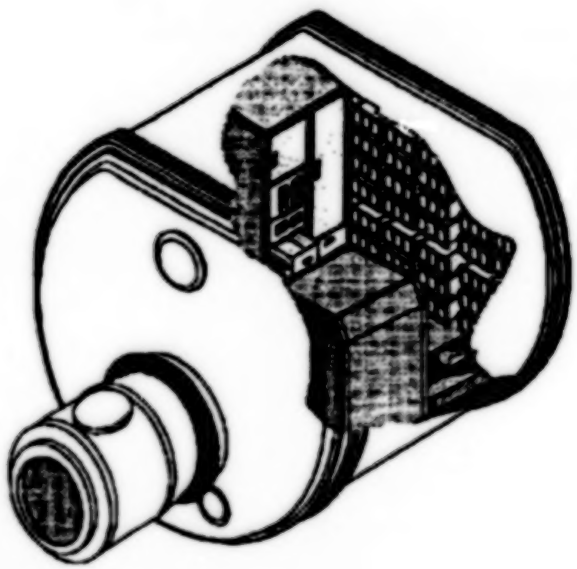
Power (Payload)

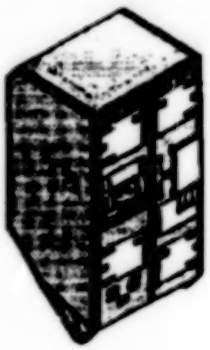
DC:	1.4 to 3.15 kW
Asc/Des:	625 W
AC:	690 VA
Cooling (Payload):	4.0 kW Liquid, 2.0 kW Air
CMD & TLM:	2 kbps, 16 kbps
Vacuum Vent:	Available

Location: Shuttle cargo bay

Available: 1992

Contact: James Ball
SPACEHAB, Inc.
600 Maryland Avenue SW, Suite 530
Washington, DC 20024
(202) 488-3483





Spacelab Middeck Experiments (SMIDEX)

The Spacelab Middeck Experiments (SMIDEX) concept was developed to fly middeck-type experiments on Spacelab, adding flight opportunities as well as an alternative to the limited space in the Shuttle's middeck. SMIDEX provides for the installation of four mounting plates into the double rack section, accommodating as many as eight middeck lockers, and up to four experiment Apparatus Containers (EACs) with Experiment Electronic Packages (EEPs) in the upper rack section. The SMIDEX structure and design allow for front access, an advantage for late experiment changeout, electrical cabling and crew interfaces. Since the mechanical and electrical interfaces between the experiments and the SMIDEX mounting plates are the same as for the middeck, no modifications of the experiments or lockers are required when flown in the Spacelab.

Up to three DC power sources and one AC power source from the Spacelab Experiment Power Switching Panel will provide power to those items requiring power via generic AC and DC cables, which are installed and routed in the rack. The cables are sized to carry 3 amps AC and 7 amps DC.

SMIDEX Load Capability

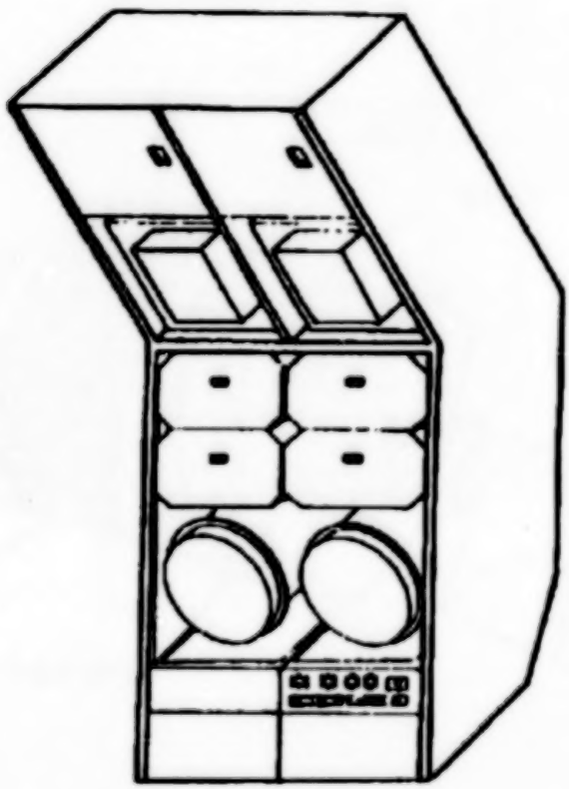
Cg*	Experiment Weight
14 in	125 lbs
13 in	133 lbs
12 in	139 lbs
11 in	142 lbs
10 in	145 lbs

*Inches from late center line

Carrier: Spacelab

Available: Now

Contact: NASA/Johnson Space Center
Customer Integration Office, Code TC4
Houston, TX 77058



Spacelab Module (SL)

Spacelab is a versatile research center that provides a shirt-sleeve laboratory aboard the Shuttle as well as accommodations for instruments that require direct exposure to the space environment or no crew interaction. It can be tailored to meet the needs of multidisciplinary and dedicated discipline missions: it accommodates both large, complex facilities and smaller apparatus. Using Spacelab, investigators may interact with their experiments in several ways: by participating as Payload Specialists; by communicating from the ground with Payload Specialists in space; or by operating experiments by remote control from the ground.

The SL configuration as flown on Spacelab-1 consists of a core segment, experiment segment and endcones, without the airlock. In the laboratory module, experiment apparatus can be contained in the experiment racks, overhead containers, areas beneath the floor, stowage containers or attached to the center aisle. A Spacelab Short Module consists of only the core segment.

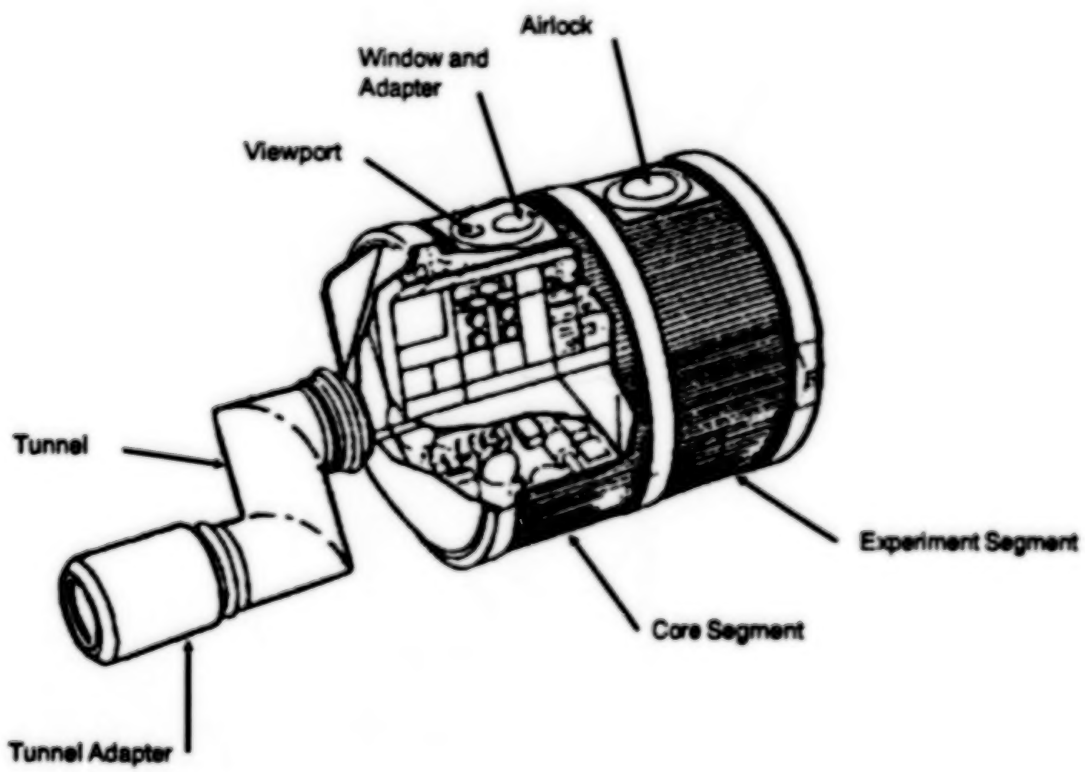
Oporational Characteristics

Dimensions:	22.8 ft L x 12.1 ft D
User Volume:	285 ft^3
User Weight:	10,033 lbs
User Power:	3.4 kW (cont), 7.7 kW (peak)
User Cooling:	4.1 kW (ave) Liquid, 5.2 kW (peak) Liquid, 3.1 kW Air
CMD & TLM:	70 kbs, 50,000 kbs max

Location: Shuttle cargo bay

Available: Two carriers are available with long lead scheduling

Contact: NASA/Marshall Space Flight Center
Code JA41
Marshall Space Flight Center, AL 35812



Spacelab Rack

The Spacelab Rack is a flight-qualified structure lining both sides of the Spacelab Module. Up to six double racks and four single racks can be installed in the long module. In addition, each module configuration contains a control center rack (part of the Command and Data Management subsystem) and a workbench rack (work space for the crew).

An Experiment Power Switching Panel (EPSP), a Remote Acquisition Unit (RAU) and the Spacelab signal interface unit are located in each rack to serve the user. Also, air cooling is provided to each rack; however, front panels must be sealed to permit satisfactory performance of the cooling loop.

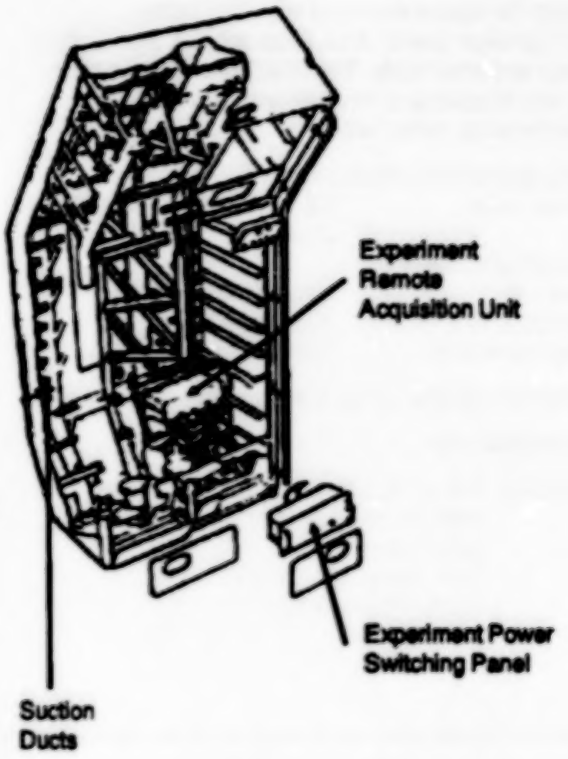
Operational Characteristics

Single Rack	
User Dimensions:	70.0 in H x 17.42 in W x 24.09 in D
User Volume:	17.32 ft^3
User Weight:	640 lbs
User Power:	3.4 kW (cont), 7.1 kW (peak)
User Cooling:	4.0 kW L, 4.5 kW A
CMD & TLM:	Mission dependent
Double Rack	
User Dimensions:	87.5 in H x 36.68 in W x 24.09 in D
User Volume:	41.3 ft^3
User Weight:	1,279 lbs
User Power:	3.4 kW (cont), 7.1 kW (peak)
User Cooling:	4.0 kW Liquid, 4.5 kW Air
CMD & TLM:	Mission dependent

Location: Spacelab module

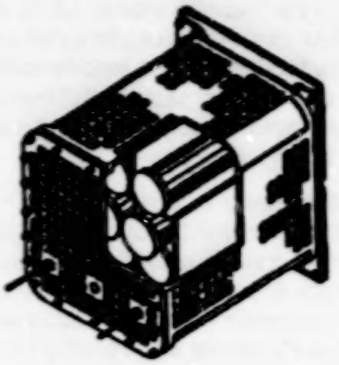
Available: Now

Contact: NASA/Marshall Space Flight Center
Spacelab Management Office, Code JA41
Marshall Space Flight Center, AL 35812



Universal Small Experiment Container (USEC)

USEC is a multipurpose experiment carrier compatible with multiple Shuttle accommodation locations and provides on-orbit access capability. USEC is qualified as a pressure vessel designed for safe handling of hazardous materials and adheres to NASA safety requirements. The lease package for USEC includes the USEC hardware and mission support related to preparation and maintenance of USEC acceptance data package. The USEC is compatible with 19-inch rack interface and middeck/SPACEHAB interface. There is a modular design for custom front and rear door utility configuration; power, data, vacuum/vent, avionics air, water and other fluids. The USEC provides on-orbit access for sample change-out and payload maintenance and servicing.



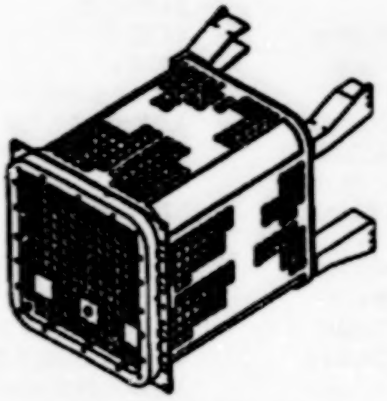
Middeck/SPACEHAB Configuration

Operational Characteristics

Dimensions:	19 in H x 17.4 in W x 20.0 in depth
Weight of middeck version:	Approximately 70 lb
Weight of rack version:	Approximately 60 lb
Payload volume:	3.2 ft^3

Location: Shuttle middeck and cargo bay carriers

Available: 1991



Spacelab Rack Configuration

Contact: Ronald E. Giuntini
Manager of Space Engineering
Wyle Laboratories
7800 Governors Drive W.
Huntsville, AL 35807
(205) 837-4411

Upper Rack Stowage Trays

A stowage tray structural enclosure is designed to house the stowage trays. It has dimensions of approximately 20 inches long by 16 inches wide by 12 inches high, is slide-mounted into the rack and attached to the front of the rack by fasteners. On the interior, metal tray guides are installed for smooth insertion of stowage trays. Metal strikers attached to the front of the enclosure are provided to mate with the latching mechanism of the trays.

Stowage trays may be removed completely from the enclosure. They have front panels with spring latches which mate with the strikers located on the enclosure. Compartments for each item of equipment may be cut out of foam to provide restraint for the contents. The mass load capability for flight use of stowage drawers or trays is 30 pounds per cubic foot of available stowage volume.

The trays are completed for 2, 5 and 7 panel unit sizes. Trays of five other sizes may be constructed. All trays have a width of 15.24 inches and depth of 19.72 inches; the heights of the trays range from 2.13 inches to 11.23 inches.

Carrier: Shuttle middeck or Spacelab

Available: Now

Contact: NASA/Johnson Space Center
Life Sciences Experiments Program
Houston, TX 77058
(713) 483-7328

Chapter 12: Shuttle Cargo Bay-Related Carriers

The Shuttle's cargo bay accommodates many kinds of experiments that do not require an astronaut's attention or manipulation. As a result, the equipment designed to support such experiments function independently of other astronaut or Shuttle activities. The user determines this selection according to the requirements of the experiment and availability of the mission.

Get-Away-Special Bridge (GAS Bridge)

The GAS Bridge is an adaptation of the Multi-Purpose Experiment Support Structure (MPESS) (See page 142). The GAS Bridge can accommodate up to 12 Get-Away-Special (GAS) cans. The advantage of this structure is that if additional space develops late in the integration process for a particular flight, the MPESS can be integrated into the cargo bay and accommodates up to 12 GAS cans.

Operational Characteristics

Dimensions:	9.38 ft H x 2.79 ft W x 14.24 ft L
Volume:	12 GAS cans @ 5.0 ft^3 each
Weight:	4,800 lbs
Power:	0 kW
Cooling:	0 kW Liquid, 0 kW Air
CMD & TLM:	N, N

Location: Shuttle cargo bay

Available: One carrier now available

Contact: NASA/Goddard Space Flight Center
Shuttle Small Payloads Project
Payloads Division, Code 740
Greenbelt, MD 20771

Get-Away-Special Canister (GAS can)

The GAS can is a standardized, cylindrical aluminum container that can be evacuated and/or pressurized. It includes an insulated exterior on the bottom and sides for thermal control (an insulated top end cap is available). A standard experiment mounting plate is used with each GAS can. While this plate may not be altered, it does include adequate provisions for the attachment of experiment packages.

GAS can operations are independent of the Shuttle other than three on/off controls activated by the crew. The user is responsible for providing electrical power, heating/cooling and data acquisition systems and must consider thoroughly the effects of temperature, vibration, acoustics, acceleration and pressure during design.

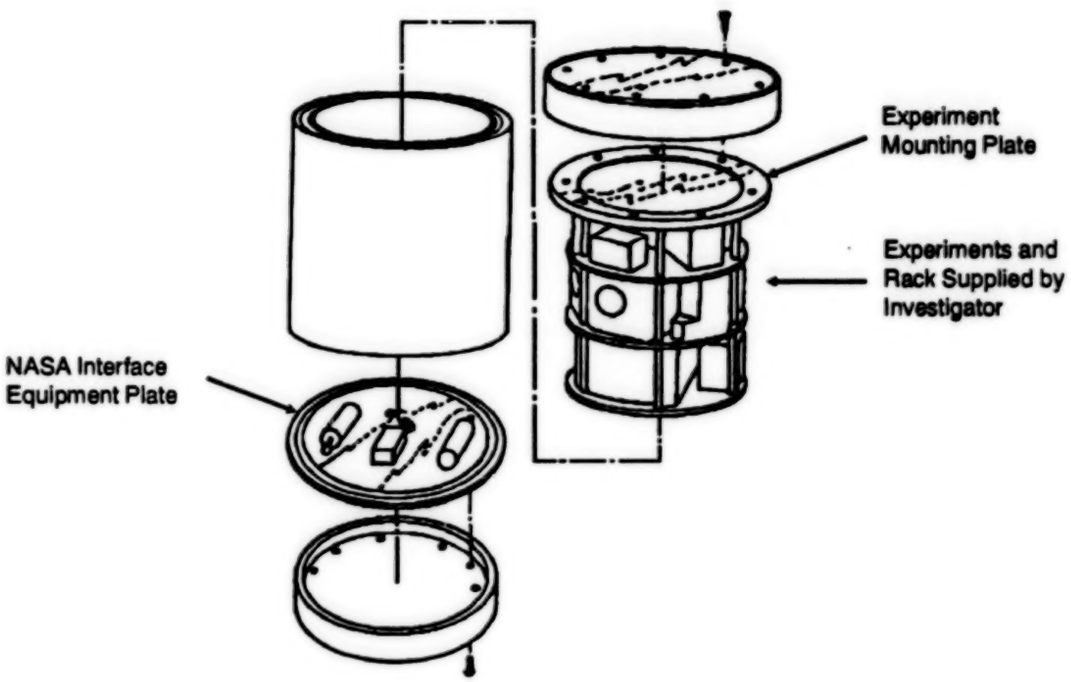
Operational Characteristics

Dimensions:	28.5 in H x 20.0 in diameter
Volume:	5.0 ft^3
Weight:	200 lbs
Power:	0 kW
Cooling:	0 kW Liquid, 0 kW Air
CMD & TLM:	N,N

Carrier: Hitchhiker-G & -M, GAS Bridge on Shuttle cargo bay

Available: Now

Contact: NASA/Goddard Space Flight Center
Shuttle Small Payloads Project
Special Division, Code 740
Greenbelt, MD 20771



Hitchhiker-G (HH-G)

Hitchhiker-G can carry up to six customer payloads weighing a total of up to 750 pounds, mounted on the side of the cargo bay. Hitchhikers are nominally carried in "bays" 2 and 3 near the forward end. Hitchhiker-G is side-mounted on the starboard side to avoid interference with the Remote Manipulator System (RMS), which is normally carried on the port side. Hitchhiker is designed with standard pre-defined electrical interfaces and also has special transparent data system features to perform electrical integration and check-out of the customer hardware on the carrier. Mechanical interfaces are simple and consist of a flat vertical plate with a 70 mm grid hole pattern or a canister similar to GAS (with or without a motorized door).

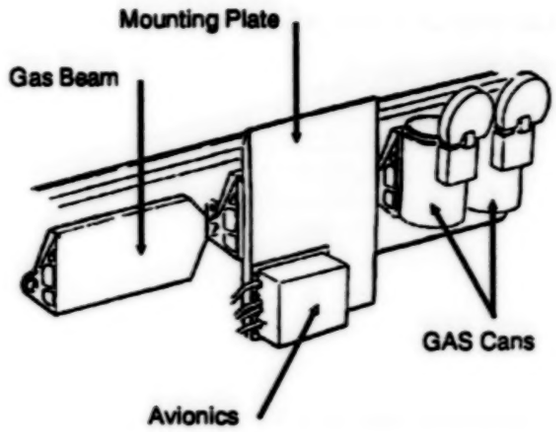
Operational Characteristics

Dimensions:	5.0 ft H x 10.0 ft L
Mtg. area:	4.2 ft x 5.0 ft plate or 2.4 ft x 3.33 ft plate (2)
Volume:	2 GAS cans
Weight:	750 lbs
Power:	1.3 kW
Cooling:	0 kW Liquid, 0 kW Air
CMD & TLM:	TBD, 1,300 kbs

Location: Shuttle cargo bay

Available: Two carriers now available

Contact: NASA/Goddard Space Flight Center
Shuttle Small Payloads Project
Payloads Division, Code 740
Greenbelt, MD 20771



Hitchhiker-M (HH-M)

Hitchhiker-M has services identical to HH-G and can carry up to 1,200 pounds of customer equipment mounted on a Multi-Purpose Experimental Support Structure (cross-bay bridge type). Hitchhikers are considered secondary payloads and should not interfere with primary payload requirements on the same mission. Unique crew activity and attitude (pointing) requirements of a limited nature (e.g. several hours) usually can be accommodated.

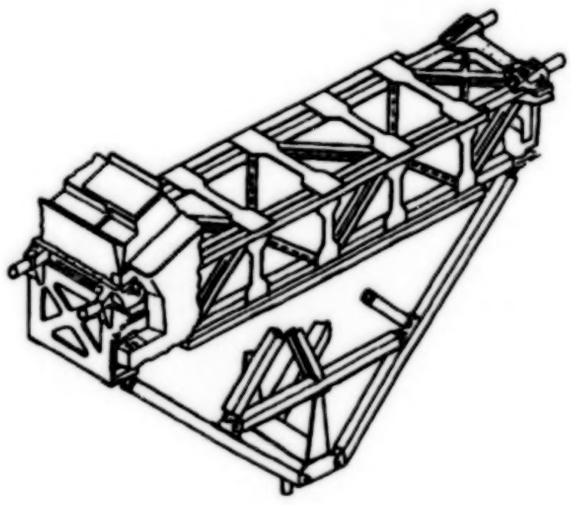
Operational Characteristics

Dimensions:	9.38 ft H x 2.79 ft W x 14.24 ft L
Mounting area:	4 plates @ 2.8 ft x 3.33 ft ea. 7 plates @ 2.4 ft x 3.33 ft ea.
Weight:	1,170 lbs
Power:	1.3 kW
Cooling:	0 kW Liquid, 0 kW Air
CMD & TLM:	8.064 kbs, 1,300 kbs

Location: Shuttle cargo bay

Available: One carrier now available

Contact: NASA/Goddard Space Flight Center
Shuttle Small Payloads Project
Payloads Division, Code 740
Greenbelt, MD 20771



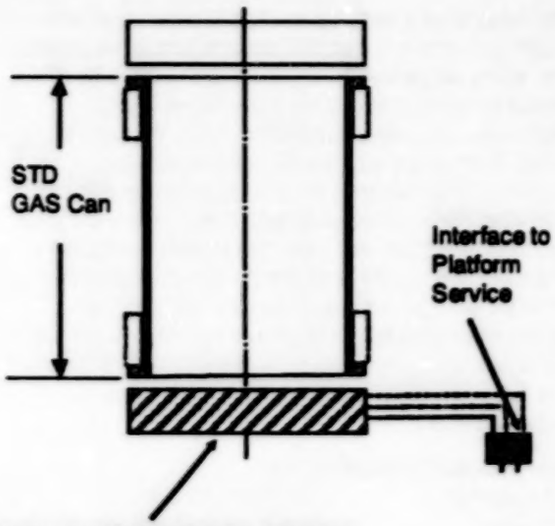
Long Duration GAS Canister with "Smart Lid"

The OUTPOST Platform (see page 171) will offer an attach location in orbit for long duration GAS Cans using a specialized container lid, which enables the user to plug directly into the OUTPOST Platform's power, communications and other subsystems. The special lid, or "Smart Lid," allows the transfer of power, command and control signals, sensor information and other services on an "as needed" basis or as part of several standard packages.

Location: Outpost Platform

Available: 1993-94

Contact: William A. Good
GLOBAL OUTPOST, Inc.
P.O. Box 4321
Highlands Ranch, CO 80126
(303) 791-6277



Smart Lid with Electronics, Interface Equipment, Wiring to Power and Communications on Platform

Materials Science Laboratory (MSL)

The Materials Science Laboratory (MSL) can accommodate a maximum of three experiment apparatus. Designated experiment equipment and subsystems mounted on the Multi-Purpose Experiment Support Structure (MPESS) form a specific configuration known as the Materials Science Laboratory. An experiment may be operated by crew members using a control panel in the Shuttle Aft Flight Deck, by the investigator who can uplink commands from the ground or by automatic programmed commands.

The MSL accommodates a variety of microgravity science apparatus and is especially adapted for large, heavy payloads. It provides structural support, power, environmental control and command and data handling, reducing the complexity of designing an experiment for a Shuttle flight.

Operational Characteristics

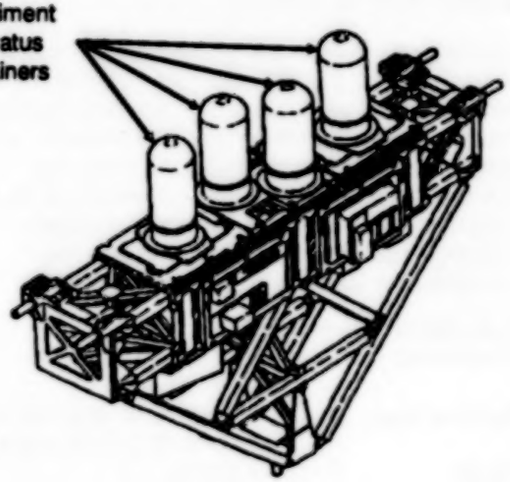
Dimensions:	9.19 ft H x 2.92 ft W x 14.47 ft L
Mtg. area:	3 plates @ 2.8 ft x 3.33 ft ea. 3 plates @ 2.4 ft x 3.33 ft ea.
User weight:	2,040 lbs
User power:	1.41 kW (cont), 2.6 kW (peak)
User cooling:	7.5 kW Liquid, 0 kW Air
CMD & TLM:	8 kbs, 1400 kbs

Location: Shuttle cargo bay

Available: One carrier now available

Contact: NASA/Marshall Space Flight Center
Code JA41
Marshall Space Flight Center, AL 35812

Experiment Apparatus Containers



MSL Experiment Apparatus Container (MSL EAC)

EACs are convenient, economical housings or covers for experiment apparatus and are integrated into the Materials Science Laboratory (MSL). The cargo bay EAC houses experiment apparatus with greater weight and power requirements than can be accommodated by the middeck EACs.

The EAC is a removable, bell-shaped containment shroud that can house a variety of experiment apparatus. The EAC has two sections: a tall shroud that encloses the experiment and a base ring section where the experiment attaches to the EAC. The cargo bay EAC is mounted on the MSF carrier and uses the carrier's host subsystems for control and support.

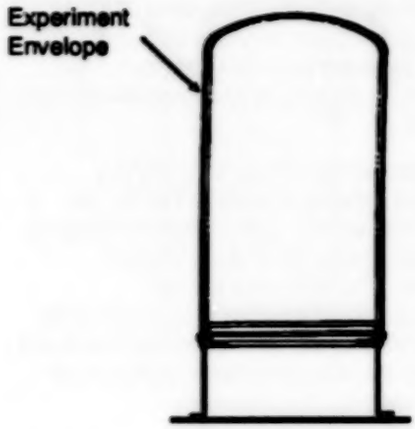
Operational Characteristics

Dimensions:	32.18 in H x 16.82 in diameter
Volume:	4.2 ft^3
Weight:	275 lbs
Power:	0.47 kW
Cooling:	0.8 kW Liquid, 0 kW Air
CMD & TLM:	TBD, 1,400 kbs max

Location: Materials Science Laboratory (MSL), Shuttle

Available: Now

Contact: NASA/Marshall Space Flight Center
Microgravity Projects, Code JA81
Marshall Space Flight Center, AL 35812



Multi-Purpose Experiment Support Structure (MPESS)

The MPESS is a generic structure designed to be integrated into the Shuttle cargo bay in a cross-bay bridge configuration. Currently, the MPESS is being utilized with the MPESS-A, the Get-Away-Special Bridge, Spartan and the Hitchhiker-M carriers; it may be combined with MPESS-A to form the MPESS-B configuration for additional weight and area capability.

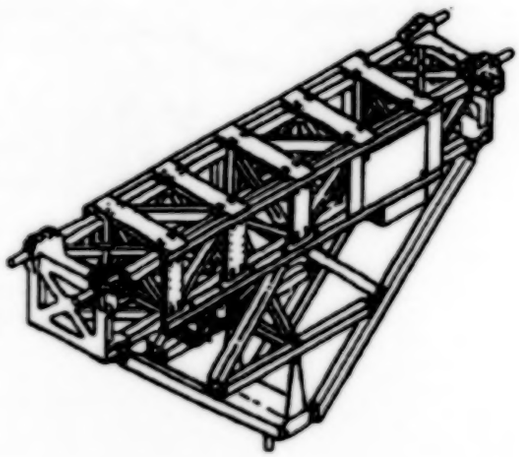
Operational Characteristics

Dimensions:	9.39 ft H x 2.79 ft W x 15.0 ft L
Mtg. area:	Mission dependent
User weight:	Up to 4,200 lbs
User power:	Not applicable
User cooling:	Mission dependent
CMD & TLM:	Mission dependent

Location: Shuttle cargo bay

Available: Seven structures are available (2 additional are under construction)

Contact: NASA/Marshall Space Flight Center
Spacelab Management Office, Code JA41
Marshall Space Flight Center, AL 35812



Retrievable Payload Carrier (RPC)

The RPC is a multi-mission payload carrier planned for launch and retrieval by the Shuttle on a regular basis. Customer payloads will fly 6-15 month missions, or longer, on the RPC for a nominal fee based on weight, volume and optional services. Industry, university and government payloads, both domestic and foreign, are accommodated by 28 pallets supporting 200-pound payloads distributed around the periphery and each face of the RPC. An extendible/retractable boom provides 40 feet of separation from the main bus of one payload. Flight kits providing unique payload support are available as an optional service.

The RPC configuration is derived from NASA's flight-proven Long Duration Exposure Facility. Its size provides more flexible Shuttle cargo manifesting capability, assuring better on-time launch and payload recovery. The RPC uses the full cross-section of the Shuttle carrier or, because of its volumetric efficiency, as an attached carrier that is not deployed. Shuttle recovery ensures low-g exposure for delicate payloads.

Operational Characteristics

Total Spacecraft weight:	8,043 lbs
Maximum payload weight:	5,600 lbs
Individual pallets support:	200-400 lbs
Mounting volume:	28 pallets, each @ 33.5 in L x 30.5 in W; depths are 3 to 40 inches
Power:	0.3-0.6 kW
CMD & TLM:	4.8 kbs (initial mission)

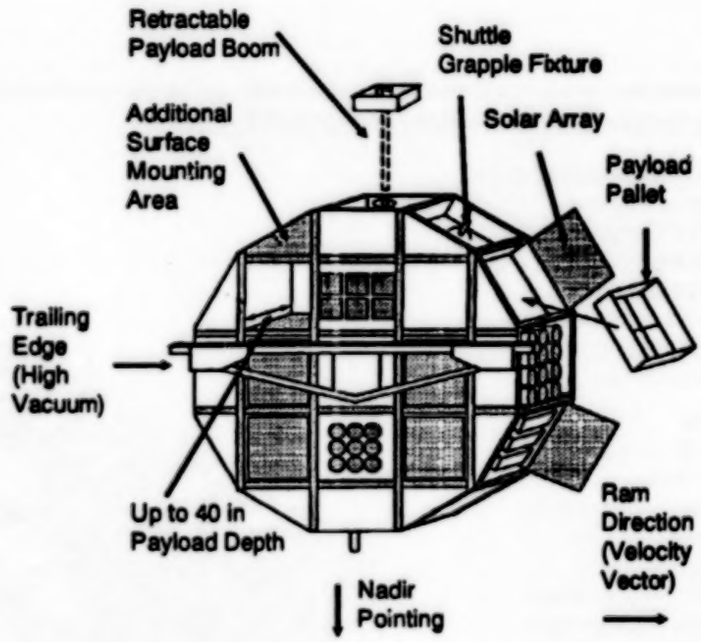
Vehicle oscillation

Roll:	1.3°	17,900 sec period
Pitch:	1.3°	30,100 sec period
Yaw:	6.8°	37,700 sec period

Carrier: Shuttle, on-orbit freeflyer

Available: 1992

Contact: Arthur T. Perry
American Space Technology, Inc.
2800 28th St., Suite 351
Santa Monica, CA 90405
(213) 450-7515



Shuttle Pallet

The Shuttle pallet is a U-shaped structure, 13 ft wide by 10 ft long. It consists of an aluminum frame covered by aluminum honeycomb skin panels. This type of construction governs the attachment provisions for experiment and subsystem equipment. Lightweight equipment and support brackets for Freon lines and cabling can be mounted directly to the inner surface skin panels. Threaded inserts arranged in a 5.5 inch square grid pattern provide the means for attachment. Each panel is capable of supporting a uniformly distributed total load of up to 1.02 lb/square foot. To mount large or heavy payloads, standard hard-point assemblies can be fastened to the intersection of the U-shaped cross members and longitudinal connecting members. Up to 24 of these hardpoints can be installed on a pallet. The pallet is directly exposed to space with the Shuttle cargo doors opened.

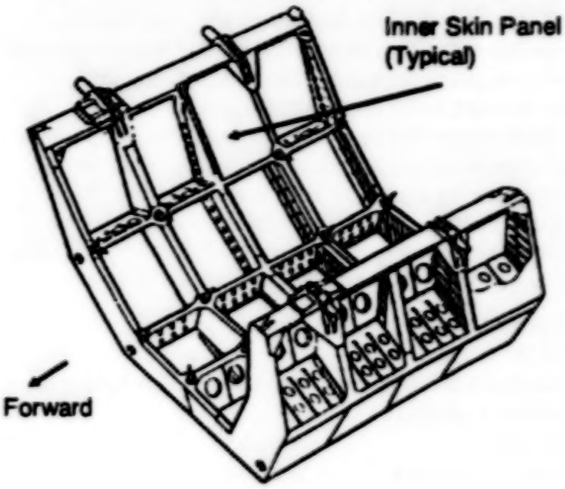
Operational Characteristics

Dimensions:	9.43 ft L x 13.12 ft W, U-shaped
User Mtg. area:	122 ft^2 to 151 ft^2
User weight:	6,856 lbs maximum
User power:	4.4 kW (cont), 8.5 kW (peak)
User cooling:	7.0 kW Liquid, 0 kW Air
CMD & TLM:	2 kbps, 50 kbps

Location: Shuttle cargo bay

Available: Now

Contact: NASA/Marshall Space Flight Center
Spacelab Management Office, Code JA41
Marshall Space Flight Center, AL 35812



Spartan Flight Support Structure (SFSS)

The Spartan base structure is a Multi-Purpose Experiment Support Structure (MPESS) with a detachable upper structure which houses unique instruments for each mission. This structure is released and retrieved by the Shuttle during the course of the flight.

The complete Spartan freeflyer carrier system consists of the Service Module (SM), the Upper Structure (US) and the Instrument Canister (IC). The Spartan is a basic standardized assembly that contains many of the subsystems necessary to support a specific mission configuration and to satisfy its requirements. The US is unique to each Spartan mission and consists of the upper housing, the IC, the Altitude Control System (ACS), pneumatics system with cold gas supply and support for the Remote Manipulator System (RMS) grapple fixture. The IC is the most common configuration for housing Spartan scientific experiments. Current configurations are cylindrical and are 17 and 22 inches in diameter. Lengths are experiment-dependent but are limited by the Shuttle cargo bay envelope to approximately 120 inches. ACS sensors required for instrument pointing may be mounted externally, on the end of the IC, or internally, co-aligned with the instrument.

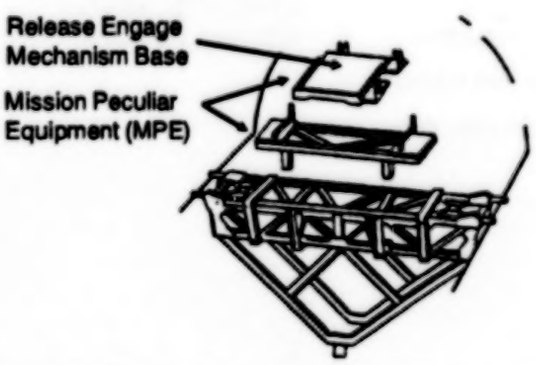
Operational Characteristics

Dimensions:	9.38 ft H x 22.79 ft W x 14.24 ft L
Mtg. area:	TBD
Weight:	5,000 lbs to users
Power:	0.28 kW
Cooling:	TBD
CMD & TLM:	TBD

Location: Shuttle cargo bay

Available: Two carriers are available

Contact: NASA/Goddard Space Flight Center
Spartan Project
Special Payloads Division, Code 740
Greenbelt, MD 20771



Standardized Experiment Module (ISEM-G)

The ITA ISEM-G consists of an aluminum aerospace structure with mounting hard points, support avionics and "housekeeping" instrumentation for experiment/payloads. The ISEM-G is designed to fit within and interface with the standard NASA 2.5 cubic feet and 5.0 cubic feet Get-Away-Special (GAS) canisters. Centrifuge tests have validated both the ISEM structure and avionics design to steady state acceleration profiles, simulating powered flight and reentry of the Shuttle and expendable launch vehicles with recovery capsules. The standard support equipment in the lower avionics section of the ISEM-G consists of a power supply, recorder, programmer-sequencer, temperature, pressure and microgravity accelerometer instrumentation. The upper section provides several mounting structure options for the experiment/payload. Current ISEM-Gs can accommodate from 3 to 10 experiments.

Operational Characteristics

5.0 ft^3 ISEM-G	
Mechanical interface:	Standard NASA GAS can
ISEM-G structure weight:	39.4 lbs
Avionics Weight:	59.9 lbs
Expt. weight capability:	108.97 lbs
Expt. volume capability:	3.5 ft^3
Dimensions:	19.75 in D x 28.25 in H
Standard battery capacity:	1.2 kWh (lead acid cells)
Standard voltage:	5, 16, 24 V
Instrumentation:	Accelerometers, pressure and temperature sensors
2.5 ft^3 ISEM-G	
Mechanical interface:	Standard NASA Gas can
ISEM-G structure weight:	19.5 lbs
Avionics Weight:	30 lbs
Expt. weight capability:	50.5 lbs
Expt. volume capability:	1.3 ft^3
Dimensions:	19.75 in D x 14.25 in H
Standard battery capacity:	0.6 kWh (lead acid cells)
Standard voltage:	5, 16, 24 V
Instrumentation:	Accelerometers, pressure and temperature sensors

Carrier: Get-Away-Special canisters

Available: Now

Contact: John M. Cassanto
Instrumentation Technology Assoc., Inc.
35 East Uwchlan Ave., Suite 300
Exton, PA 19341
(215) 363-8343, Fax (215) 363-3869

Standardized Experiment Module (ISEM-H)

The ITA Standardized Experiment Module is designed to be compatible with NASA's Hitchhiker-M across-the-bay carrier. The ISEM-H consists of three basic elements: an outer shell pressure vessel, an interior shelf structure for mounting experiments, and interface avionics which tap into the Shuttle's resources and distribute them to user experiments. One large payload or smaller multiple payloads can be flown in the ISEM-H. The internal environment can be maintained at one atmosphere or can be vented to the vacuum of space.

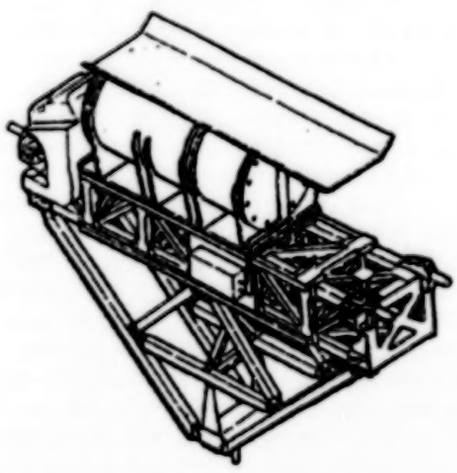
Operational Characteristics

Payload:	850 lbs
Volume:	To 50 cubic feet
Power:	1300 W
Energy:	5 kWh to 13.5 kWh/day
Heat rejection:	approximately 900 W

Carrier: Hitchhiker-M

Available: Now

Contact: John M. Cassanto
Instrumentation Technology Assoc., Inc.
35 East Uwchlan Ave., Suite 300
Exton, PA 19341
(215) 363-8343, Fax (215) 363-8569



Wake Shield Facility (WSF)

The WSF is designed to utilize the ultravacuum (10^{-14} torr on the wake side) of space to produce new electronic and superconductivity thin film materials and devices.

The principal experiment/support systems include:

- Wake Shield
- Shuttle cross-bay carrier
- Experiment attachment system
- Data acquisition and process control system
- Electrical power system

In addition, four payload containers (canisters) will be mounted on the WSF carrier for additional payload capabilities with power, command and data resources. This additional payload capability is available for microgravity, space exposure and space vacuum experiments. As a freeflyer, the Wake Shield Facility also can accommodate additional microgravity and space exposure payloads.

Operational Characteristics (as deployed)

Size:	12 ft diameter
Weight:	Up to 6,000 lbs
Power:	28 Vdc-42 kW-Hrs (batteries)
Vacuum:	10^{-14} torr behind Wake Shield
CMD & TLM:	S-band, 16 kbps (includes video)

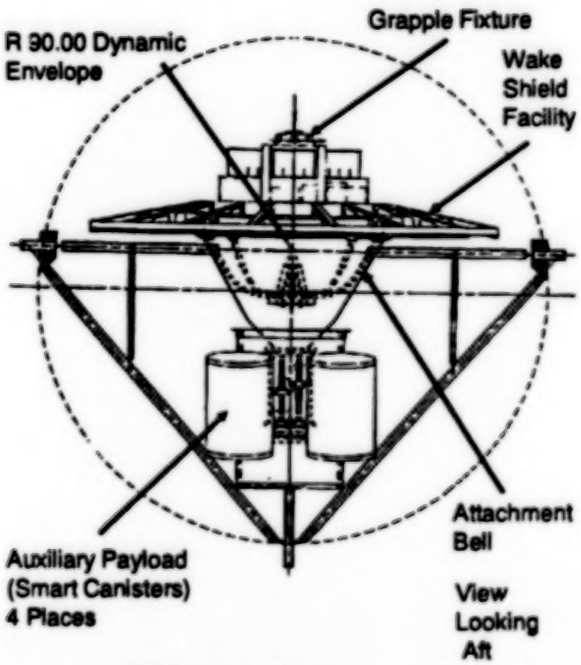
WSF Carrier Operational Characteristics

Dimensions:	9.4 ft H x 3.0 ft W x 15.0 ft L
Weight:	up to 4,600 lbs
Mounting Area:	Mission dependent
Power:	28 Vdc-1,000 W
Cooling:	Passive radiation
CMD & TLM:	16 kbps (includes video)

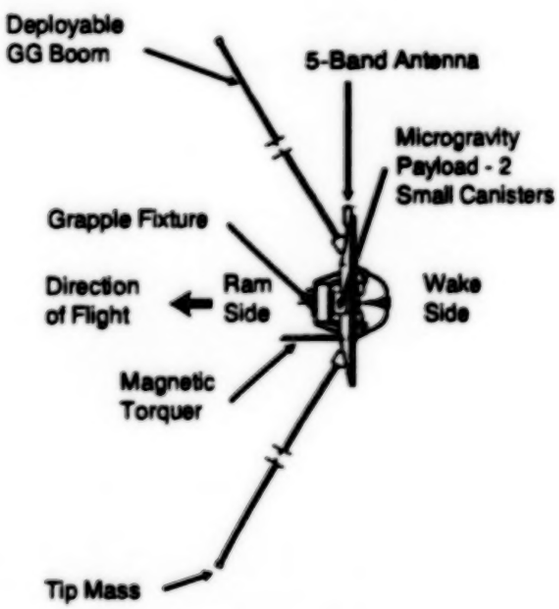
Carrier: Shuttle cargo bay

Available: Under construction by Space Industries, Inc., and CCDS members for flight as a freeflyer with the Shuttle in 1992.

Contact: Alex Ignatiev, Director
Space Vacuum Epitaxy Center
University of Houston
Science and Research, Building 1
Houston, TX 77204-5507
(713) 749-3701



WSF Carrier Assembly



WSF Free-Flyer

Chapter 13: Freeflyers and Satellites

Another opportunity for on-orbit experimentation lies in freeflyers and satellites that are launched into orbit by expendable launch vehicles. These cannot be man-tended and have limitations for control and data-gathering at present. However, with more experience in the design and operation of freeflyers, the conditions for experiments are likely to improve considerably.

Eyesat Miniature Communication Satellite

Originally developed by AMSAT, this small digital communications satellite technology now is available commercially. Four satellites were launched in January 1990 as secondary payloads on the Ariane IV vehicle. All are operating flawlessly in a 810 km sun-synchronous orbit. This low cost, high performance satellite is capable of digital voice, data, picture and fax message transmissions in a store-and-forward or transponder mode. Data rates of 4800 baud with 8 Megabytes of on-board computer memory permit a broad range of applications. Extra volume can accommodate a small, low power sensor or special communications package.

Operational Characteristics

Physical:	23 cm cube; 9.5 kg
Average power:	8 to 10 watts
Payload power:	4 W continuous; 50 W maximum
Stabilization:	Passive magnetic with solar spin
Operating Frequency:	UHF, VHF & S-Band downlink, VHF uplink
Available Channels:	5 Receivers

1200 to 9600 baud
15 kHz bandwidth, 20 kHz spacing
2 Transmitters
Binary PSK provides 19.2 kbits (omni)
56 kbits (gain antenna) @ 400 MHz

Power Requirements:	RF output: 2 to 4 W @ 75% eff. (300 to 1000 MHz)
CPU:	2 W peak
Receiver:	260 milliwatts
Computer:	NEC CMOS V-40 microprocessor 10 Mbytes RAM; 9.2 MHz oscillator 256K RAM EDAC memory Multi-tasking environment Direct Memory Access

Carrier: Expendable launch vehicles

Available: Now

Contact: Dino A. Lorenzini, V.P., Operations
Interferometrics, Inc.
8150 Leesburg Pike, Suite 1400
Vienna, VA 22182-2799
(703) 790-8500, Fax (703) 848-2492

Multi-Use Lightsat Environment (MULE)

The Multi-Use Lightsat Environment (MULE) is a modular space vehicle that can handle all types of small payloads up to 250 pounds in mass, injected to orbits of up to 450 nautical miles. The system is compatible with launch on Pegasus or Taurus vehicles (see pages 207-210). The system concept is under development by Spectrum Research, Inc. and the Defense Advanced Research Projects Agency (DARPA).

Spectrum Research, Inc. specializes in the conceptualization, mission analysis, design, manufacture and test of sophisticated small space vehicles, including those in the low-cost, quick-reaction class. The vehicle depicted here is Spectrum's "Mini-Metsat" small weather satellite design, which incorporates the ITT Advanced Very High Resolution Radiometer (AVHRR) payload.

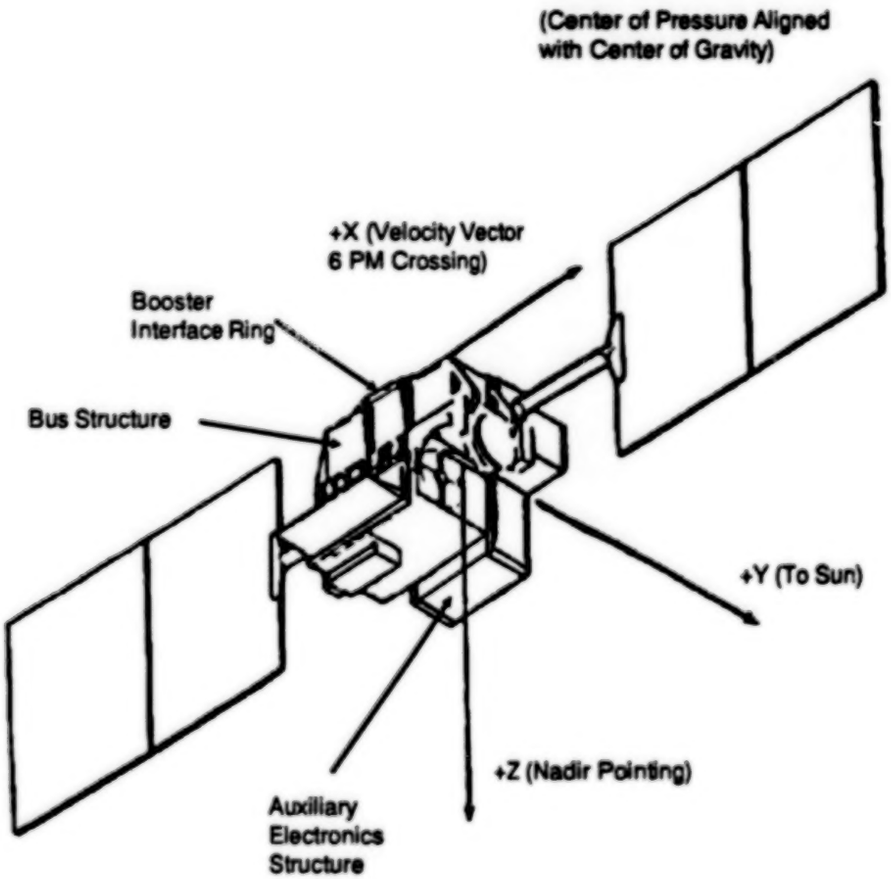
Operational Characteristics

Mass:	Approx. 500 lb total at insertion
Mission Duration:	Up to 3 years
Orbits:	LEO circular or elliptical
Payload Power:	180 W (typical)
Attitude Control:	3-Axis, .1 degrees

Carrier: Pegasus or Taurus launch vehicles

Available: Under development

Contact: W. David Thompson, President
Spectrum Research, Inc.
525 South Douglas Street
El Segundo, CA 90245
(213) 643-9303, Fax (213) 643-5369



PegaStar Low-Cost "Bus"

The PegaStar is being designed as a low cost multi-purpose spacecraft platform for use with Pegasus and Pegasus-derived launch vehicles (see page 207). Using many of the same systems that operate the Pegasus vehicle, PegaStar will be built around the third stage of Pegasus to provide the "housekeeping" services necessary to support customer-provided instruments, communications devices and other scientific equipment in orbit. Because the PegaStar platform will provide both the rocket and the payload with avionics and data systems, the need to duplicate these functions in a separate satellite is eliminated, thus improving overall performance. As a result, PegaStar will be able to accommodate heavier, more sophisticated payloads into orbit for the same, or lower, launch cost than otherwise would be required.

For example, a spacecraft in a 400 nautical mile, sun-synchronous orbit with an assumed typical payload/experiment mass fraction (25%) for the separable spacecraft, could be 43% heavier if orbited with a PegaStar bus. The actual percentage improvement for a given mission can be evaluated using customer specific mission requirements. Since the Pegasus Stage 3 and Taurus Stage 4 are almost identical, the PegaStar concept can be executed on either launch vehicle. This enables a wide range of payload weight and orbit capabilities to be supported by the PegaStar concept.

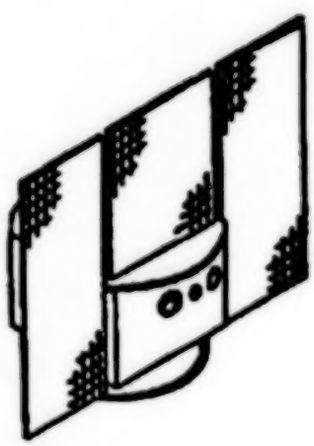
The actual configuration of a PegaStar for a specific mission develops as a function of meeting customer requirements. The flexible design depends on specific payload/experiment requirements such as orbit altitude and inclination; power; pointing accuracy and knowledge; telemetry (up and down), thermal; and on-orbit lifetime. Based on these requirements, the vehicle may be three-axis, spin or gravity-gradient stabilized. PegaStar can be configured with fixed or steerable solar arrays, with power levels to as much as one kilowatt.

Carrier: Pegasus or Taurus launch vehicles

Available: Under development

Contact: Robert E. Lindberg
Orbital Sciences Corporation
Space Systems Division
12500 Fair Lakes Circle
Fairfax, VA 22033
(703) 631-3600

Basic PegaStar Bus



3-Axis Sun Synchronous

Standard Affordable Small Spacecraft

The SCI Standard Affordable Small Spacecraft (SASS) is a highly adaptable spacecraft bus designed to accommodate a variety of payloads including: experimental, communications, remote sensing, reconnaissance and tactical missions for both government and commercial users.

SASS is compatible with Pegasus, Scout or other small expendable (soft or hard) launchers and readily provides three-axis, gravity gradient or spin-stabilized configurations.

The driving design criteria for SASS is user affordability while maintaining excellent reliability and performance characteristics. Depending on the mission requirements, power can be provided by body-mounted Silicon or Gallium Arsenide solar panels (providing extremely low atmospheric drag), or articulating sun-tracking arrays.

SASS can maintain a circular or elliptical Low Earth Orbit for various altitudes, inclinations and mission durations. The SCI spacecraft supports a wide variety of payload types and dimensions.

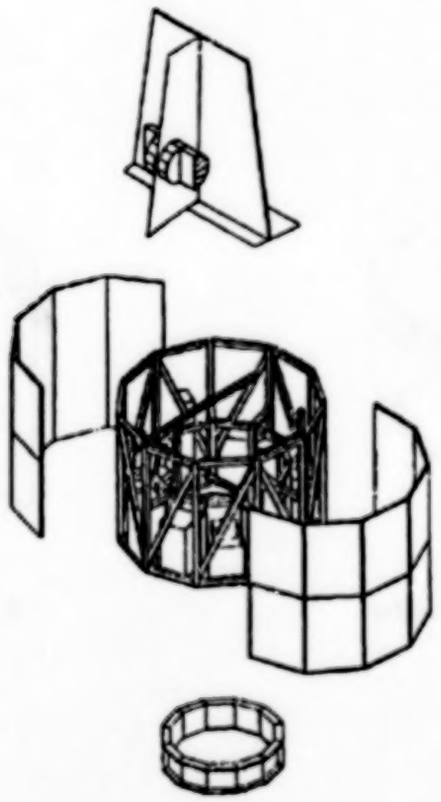
Operational Characteristics

Power consumed by spacecraft:	35 watts, 42 watts peak
Power to payload:	60 watts average, 106 watts peak with body mounted solar arrays. Available power can be increased using articulating arrays.
Basic spacecraft weight:	<226 lbs, >200 lbs available for payload with no modification. Can be expanded to accommodate heavier payloads with minor modification.

Carrier: SLV, ELV, Pegasus, Scout or equivalent vehicles

Available: Now

Contact: Ernie Blair
SCI Systems, Inc.
8600 South Memorial Parkway
Huntsville, AL 35802
(205) 882-4432



T-SAT

T-SAT is a generic, low-cost, 3-axis stabilized satellite designed to accommodate various scientific, commercial and military payloads. The same type of construction is used for four basic models, ranging from 18 inches long by 18 inches diameter for a Get-Away Special (GAS) to a 38 inch long by 36 inch diameter for a Scout or Pegasus launch vehicle; a commercial version is 48 inches long by 45 inches in diameter for an Atlas/Centaur secondary payload launch.

Payload capability is 50-250 pounds, depending on the T-SAT model selected. The form factor of each satellite is cylindrical monocoque structure. Power is supplied with body-mounted solar cells augmented by fixed deployable panels that provide 30-300 watts of orbit average power.

Operational Characteristics (T-36 model)

Dimensions:	38 in H x 36 in diameter
Volume:	24.94 ft^3
Weight:	470 lbs
Power:	115 watts average (EOL 3 years) 28 +/-4 Vdc
Payload temperature:	32-95° F
CMD and TLM:	1 kbps, 10.2 and 833 kbps
Control system:	Bias momentum
Pointing accuracy:	0.3°
Orbit change:	Thrust vector control (860 fps)

Carrier: Pegasus, Scout or equivalent

Available: Now

Contact: INTRASPACE Corporation
421 West 900 North
North Salt Lake City, UT 84054
(801) 292-0440, Fax (801) 292-6341

Chapter 14: External Tank Applications

The Shuttle's external tank (ET) carries the liquid fuels that power the main engines of the vehicle and serves as a "backbone" to support the solid fuel booster rockets as well as the Shuttle itself. Under current launch scenarios, when the Shuttle enters an orbit in space, its expended, external tank is jettisoned into the lower atmosphere, where it disintegrates into the ocean.

Each discarded tank weighs 34 tons and comprises 72,000 cubic feet of pressurized volume and up to 10 tons of residual hydrogen and oxygen fuel. During current Shuttle flights, the discarded tanks reach 99 percent of orbital velocity and remain in space for up to an hour before they fall.

Between 1982 and 1987, a series of reports and recommendations by various government and nongovernment organizations advanced the concept of developing ET's for useful applications in space. In 1988, NASA published an announcement of opportunity that requested expressions of interest from the private sector for commercial and academic approaches for the use of expended ETs. Under the terms of each of the agreements, NASA will provide five ETs after studies and engineering designs are completed.

Global Outpost, Inc. of Alexandria, VA, and the University Corporation for Atmospheric Research (UCAR), of Boulder, CO, have signed separate agreements with NASA for the use of the expended ETs in orbit. Their plans and designs are included in this chapter.

OUTPOST Platform

GLOBAL OUTPOST, Inc. plans to put an External Tank (ET) in orbit with NASA's cooperation and salvage it with the OUTPOST Subsystems Package. The company is offering innovative research and testing opportunities as follows:

Large Space Structures Research, such as assembly development, long duration exposure materials testing, orbital latch and mechanism tests, EVA assembly tests and robotic assembly development. The existing assembly effort can be modified to produce a Large Space Structures Testbed. GLOBAL OUTPOST is proceeding to develop the truss, anticipate it will be compatible with the Space Station truss and will entertain cooperative ventures with entrepreneurial, commercial and government organizations.

Tether Research will include tether technology development and testing location in Low Earth Orbit. The platform is unpressurized and unmanned and includes the appropriate reduced safety restrictions. The attachment location offers tether technology development projects with an alternative to manned vehicle systems. The platform also can provide storage for research hardware.

Commercial materials processing development and testing of commercial production facilities will be possible on the OUTPOST Platform. The platform is expected to be revisited by the Shuttle on a non-priority basis and by other transportation vehicles. The return of product can be via the Shuttle, other vehicles or by reentry capsules.

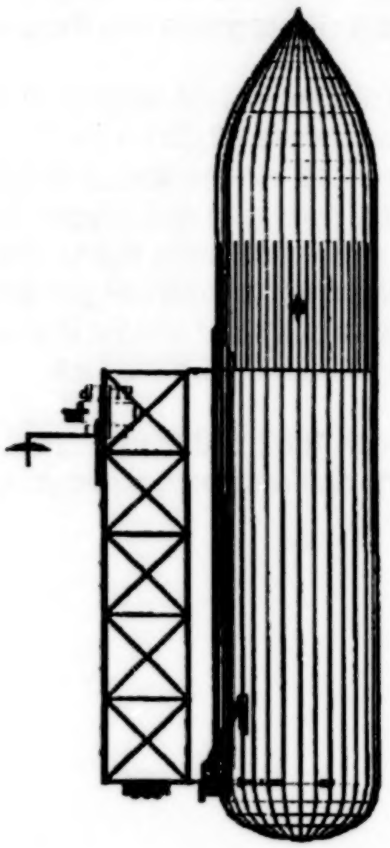
The structure will be available for the attachment of Earth viewing sensors with access to power and communications. It cannot provide fine pointing, therefore all sensors and cameras must provide required pointing capability. The attachment location for sensor research provides an unobstructed view below the platform in addition to the structural, electrical, communications, command and control and other services. Limited robotic services on an as-needed basis may be available for servicing of sensor, microgravity and life sciences payloads.

The OUTPOST Platform is an External Tank-derived commercial facility in Low Earth Orbit that will provide long duration flight testing services and development to commercial and government customers. GLOBAL OUTPOST is developing the platform under a signed NASA "Enabling Agreement." The 154-foot long platform will use the gravity-gradient stable platform to provide commercial services such as power, communications and other relatively simple services an order of magnitude less capable than the Space Station. Services will be offered in a phased manner as the market develops in orbit.

Location: On orbit

Available: 1993-1994

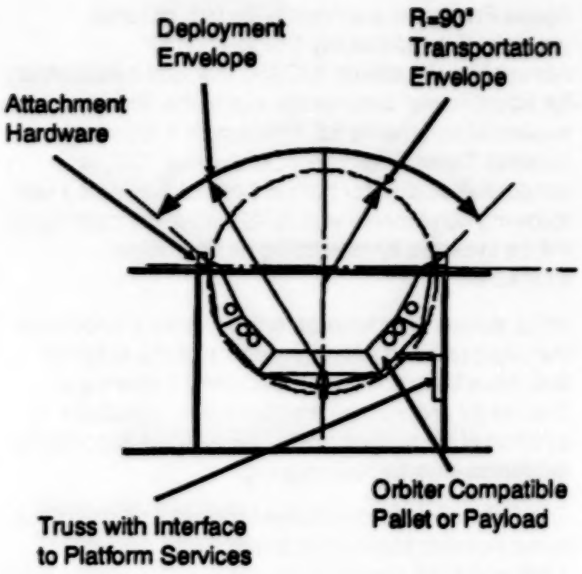
Contact: William A. Good
GLOBAL OUTPOST, Inc.
P.O. Box 4321
Highlands Ranch, CO 80126
(303) 791-6277



OUTPOST Platform (continued)

Orbital Pallet Attach Location

The OUTPOST Platform will offer a standard pallet attach location that will provide structural, electrical, thermal, communications, command and control and other services to hardware packages. The attached hardware on the truss is expected to be compatible with the Space Station attachment hardware and will offer access through a standard interface to the commercial services available from the platform. The pallets will be available in quarter, half and full Spacelab pallet sizes. The deployment of payloads from the 90 inch radius transportation envelope is possible.

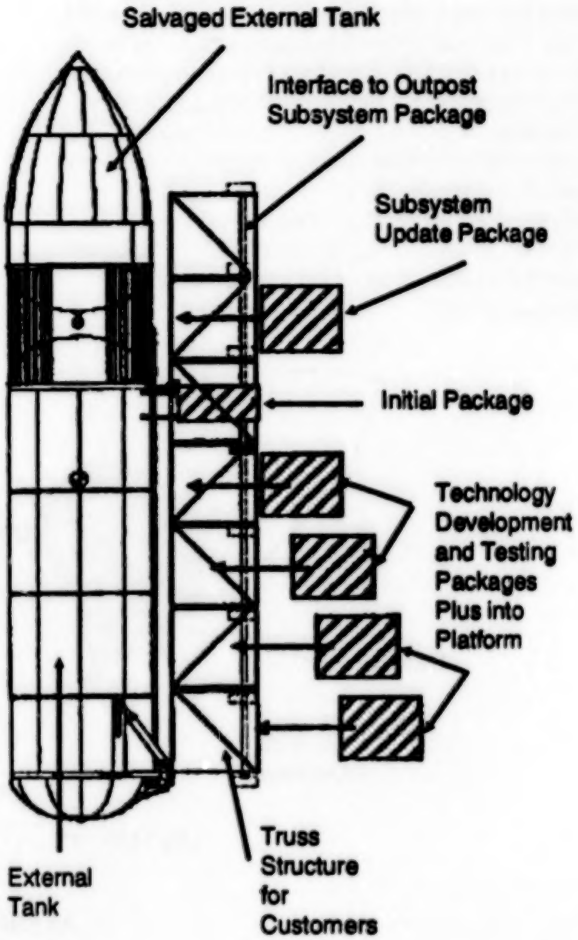


Orbital Space Effects and Materials Exposure Facility

The OUTPOST Platform will offer a long duration exposure tray attach location. The commercial service tray is similar to and will accommodate existing Long Duration Exposure Facility (LDEF) Tray experiments. It also will permit periodic monitoring of long duration flight testing of materials through the communications subsystem and the development of other activities contained in the tray.

Technology Development and Testing Location

The OUTPOST Platform will offer a "plug in" location for technology development and testing packages. The attachment location provides structural, electrical, thermal, communications, command and control and other services to hardware packages designed by other developers. The attached hardware can be installed via the remote manipulator system (RMS), or by other methods, and plugs into the commercial services available from the subsystem package. The services will be available on an "as required basis" and can flow potentially in either direction. The "plug in" service offers technology development projects an alternative to creating a separate satellite for long duration space testing.



Space Phoenix Program

Space Phoenix is a university-based, national program of the University Corporation for Atmospheric Research (UCAR) that was established for scientific and commercial use of the Shuttle's expended external tanks. The program manager, External Tanks Corporation, of Boulder, CO, is conducting studies for both suborbital and orbital use, following agreements with NASA whereby used tanks will be available for retrofitting as productive spacecraft.

Initial studies to provide an enclosure for payloads in the unpressurized intertank section of the external tank have been completed, with NASA oversight. Studies for pressurized environments, including the addition of life support and other systems required for habitation on-orbit, are ongoing.

The Company's planned development and use of the tanks includes phased flight sequences between 1992 and 1996, based on four levels of progressively increasing capability. Phases 1 and 2, for payload module testing, will include five suborbital flights. Phase 3 will test the capability to place the unpressurized external tank into orbit; stabilize, control and use it effectively; and safely dispose of it. Phase 4 will incorporate the systems required to provide a pressurized habitable environment in one or both of the propellant tanks. Each of the four phases will be initiated with a flight that incorporates sufficient instrumentation to evaluate system performance and obtain environmental and flight dynamics data. Analysis of the information obtained will be used to verify the design and fabrication of both external tank systems and equipment to be used on each subsequent flight.

External tank suborbital uses include: measurement of lower temperature density, chemical release, recoverable reentry body research and deployment of small, freeflying spacecraft.

External tank orbital uses include: storage facilities in support of Space Station Freedom, platforms for hazardous operations or experiments, propellant depots, mother spacecraft for tether operations, variable-g test facilities, power facilities and bioregenerative facilities.

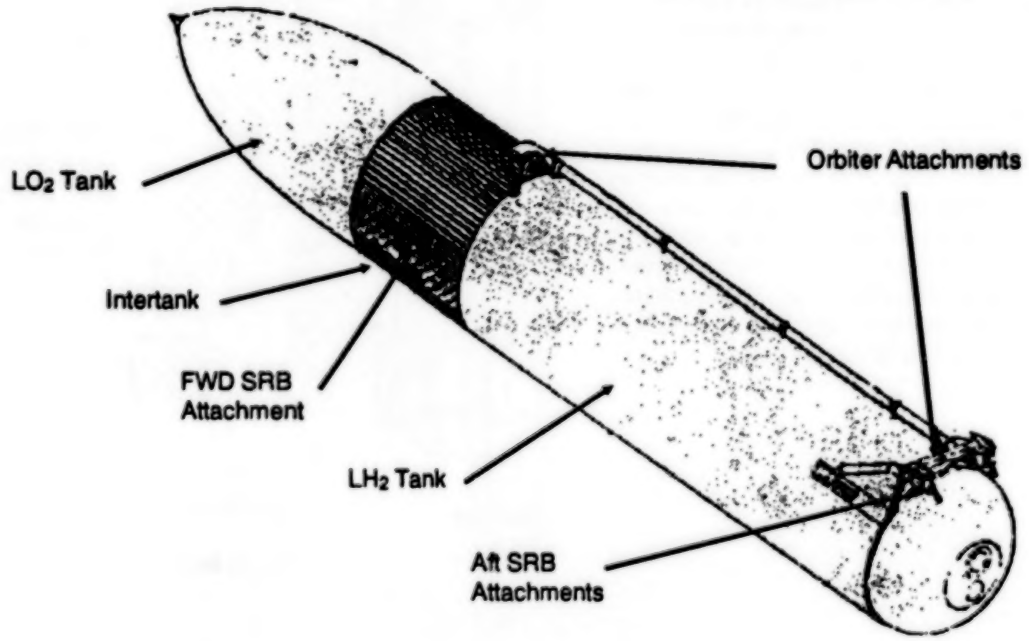
External Tank Characteristics

Dimensions:	153.8 ft long 27.6 ft in diameter
Volume:	74,000 cubic feet
Weight:	69,000 lbs empty; 1,660,000 lbs with propellants
Residual Fuel:	8,000 to 20,000 lbs of cryogenic and gaseous hydrogen and oxygen
Suborbital:	70 minutes of near-zero gravity and 17,000 mile trajectory after separation from the Shuttle
Orbital:	Altitudes between 300 and 500 km at Shuttle-compatible inclinations

Location: On orbit

Available: Under development

Contact: Randolph H. Ware, President
External Tanks Corporation (ETCO)
1877 Broadway
Boulder, CO 80302
(303) 444-6221, Fax (303) 444-7047



Chapter 15: Support Hardware

Development of the numerous carrier and mounting structures for payloads carried on the Shuttle, expendable launch vehicles, sounding rockets, aircraft and balloons has served as a catalyst for the design and manufacture of various pieces of connectors and support hardware. Many of these devices may be applicable to equipment functions on Earth and, as such, are space-derived products in their own right.

Fasteners for Use in Space

TRUSS-LOK (56547)
The TRUSS-LOK is a unique mechanical joint used to assemble erectable space structures such as Space Station truss-work. It can be operated quickly and efficiently even with large astronaut gloves used during EVA. Parts have been thoroughly tested to insure easy operation in space.

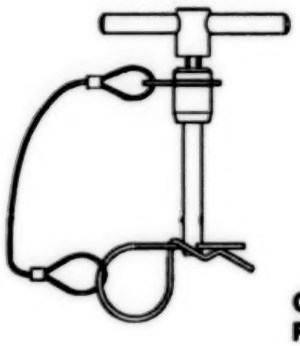
Quick Release Fasteners (53952)
BALL-LOK quick release pins are used to attach portable foot restraints to any structure during EVA. The positive locking pins can be removed easily, even while wearing astronaut gloves. Over 10,000 special designs are available. Custom designs can be ordered as required.

Adjustable Diameter Pins (ADP223)
Expanding diameter pins are used in the Shuttle bay to provide restraints on all cargo. They can be released easily by lifting the cam handle. Expanding segments fill the hole completely, thereby eliminating any vibration. They also can be used to align parts during assembly. These are the same type of adjustable fasteners that hold the rotor blades on military aircraft.

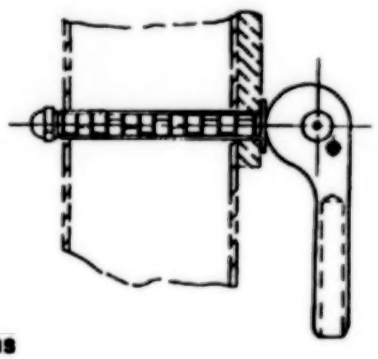
Available: Now

Contact: David Ladin
Avibank Manufacturing, Inc.
210 South Victory Boulevard, Box 391
Burbank, CA 91503-0391
(818) 843-4330

TRUSS-LOK



Quick Release Fasteners



Adjustable Diameter Pins

Interconnecting Devices

Interconnecting devices or connectors provide the mechanical operation for coupling and decoupling circuit elements. As connectors will be used by astronauts in extra vehicular activity, in a shirt-sleeve environment and, possibly, with remote manipulators, they must be easy to use and have mechanism commonality.

The 882 Series of Space Related Connectors

Engagement on the 882 family of connectors can be accomplished with angular misalignment up to +/-10 degrees and lateral misalignment up to +/-12 inch. The scoop-proof feature prevents inadvertent damage to contacts. The patented anti-bind roll-off feature prevents shell binding caused by side loads during separation. Connector materials are qualified to the stringent requirements of ASTM E 595-84 and the NASA Vacuum Stability requirements of SP-R-0022. Mater connectors with backshells exhibit a leakage attenuation of 60 db minimum over the frequency range from 10 kHz to 100 MHz and 40 db minimum over the frequency range from 100 MHz to 10 GHz. This connector allows the general shielding requirements necessary for the design of electroexplosive subsystems per MIL-STD-1512.

Operational Characteristics

Qualified to NASA/GSFC Specification S-700-42

Insulation Resistance:	5,000 Megohms minimum contact to contact or contact shell
Dielectric Withstanding Voltage:	1,000 VAC at sea level contact to contact or contact to shell
Vibration:	20 g's from 10 Hz to 2 kHz per MIL-STD-202, method 204
Physical Shock:	Per MIL-STD-202, method 213, condition G
Temperature Range:	-65° C to +125° C operating range
Thermal Shock:	Per MIL-STD-1344, method 1003.1, Condition A
Salt Spray:	Per MIL-STD-202, method 101, Condition B
Moisture Resistance:	Per MIL-STD-202, method 106
Durability:	250 mate and demate cycles

Robocon Series

This series of subminiature connectors has been designed for robotic/manipulator hand, EVA glove and blind-mate modes of operation for serviceable spacecraft, payloads and instrumentation applications. The connector incorporates the scoop-proof, EMI, backshell and other features of the MMS S-700-42 blind-mate connector technology and includes the use of long-lasting, low-insertion/low-withdrawal force, low-resistance contacts. For the manipulator, hand and EVA glove modes, the connectors are equipped with an automatic latching mechanism which retains the mated connector until the release mechanism is pressed, permitting easy release of the mated pairs. For blind-mate applications, one of the connector halves is firmly mounted with the opposite half float-mounted to provide a +/- 10 degree and +/-0.12 inch translational error without bonding contacts. There are plans for 30, 60 and 90 contact versions, as well as provision for coaxial, twinaxial, triaxial and optical couplers. Models have been made of a larger version for Space Station power distribution use employing a flat ribbon form of interconnection.

Operational Characteristics

Insulation Resistance:	5,000 Megohms minimum contact to contact to shell
Dielectric Withstanding Voltage:	1,000 VAC at sea level contact to contact to shell
Vibration:	20 G's from 10 Hz to 2 kHz per MIL-STD-202, method 204
Physical Shock:	Per MIL-STD-202, method 213, condition G
Temperature Range:	-65° C to +125° C operating range
Thermal Shock:	Per MIL-STD-1344, method 1003.1, condition A
Salt Spray:	Per MIL-STD-202, method 101, condition B
Moisture Resistance:	Per MIL-STD-202, method 106
Durability:	500 mate and demate cycles

Available: Concept models of the subminiature and power type of Robocons have been designed, produced and given preliminary tests.

Contact: G & H Technology, Inc.
Special Products Division
1649 17th Street
Santa Monica, CA 90404
(213) 450-0561, Fax (213) 452-5478

Motorized Door Assembly (MDA)

The MDA is designed to cover the aperture of a Get-Away-Special (GAS) Can during flight on the Shuttle. It operates from internal power in the same or another can or from Shuttle power. Commands to open and shut the door are from the Shuttle cabin. The MDA simply can cover the can aperture or it can serve as a hermetic seal if vacuum or pressurization by a gas is needed. The mechanical mechanism keeps pressure on an "O" ring seal until the opening command is activated, in space, in the sealed model. Optical components, such as mirrors, can be mounted to the inside of the door to provide a method for directing the viewing path of optical or microwave sensors.

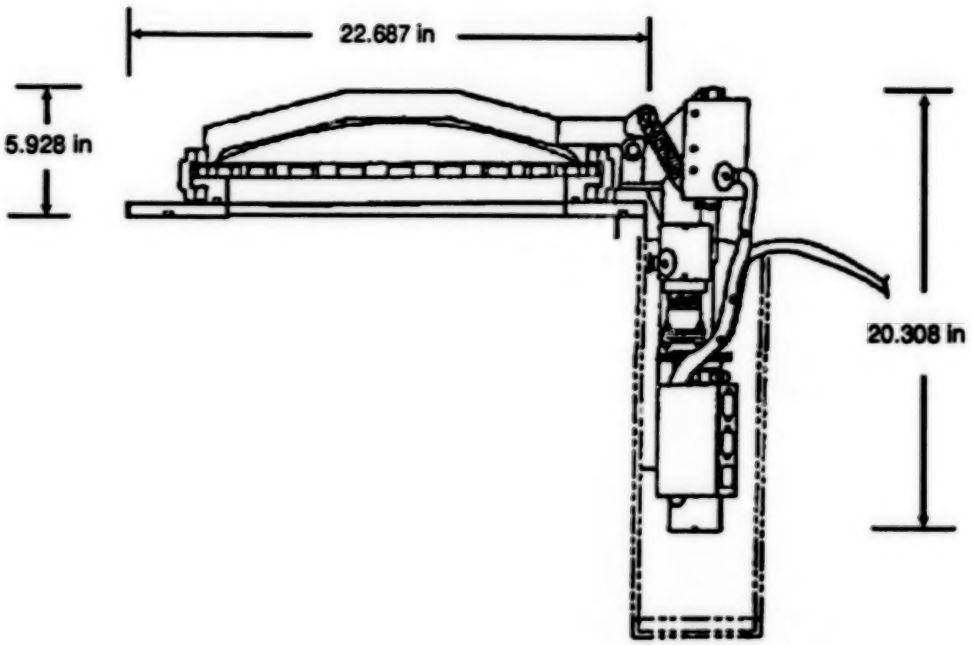
Operational Characteristics

Weight:	85 pounds in the nominal configuration, varies with mode, e.g. pressure sealed, optics mounted
Power:	200 W maximum during opening and closing
Dimensions:	As shown in drawing

Location: GAS Cans on Shuttle cargo bay

Available: Now, 4 months after receipt of order

Contact: Harvey E. Rice, Jr., Vice President
International Development &
Energy Associates, Inc.
14440 Cherry Lane Court, Suite 100
Laurel, MD 20707
(301) 369-9422



Section Five: Processing & Integration

Payload processing involves the ground-based operations required to prepare payloads, including integration with launch vehicles, for launch into space. A variety of facilities, equipment and expertise is required to meet payload processing requirements.

Typical launch site operations for large, deployable spacecraft include post-shipment assembly and checkout of the spacecraft; installation of hazardous elements, such as solid and liquid propellants; post-shipment inspection and assembly of the perigee stage; mating of the spacecraft and the perigee stage; and delivery of the payload assembly to the launch facility. Smaller payloads, such as those prepared by commercial developers for launch on the Shuttle, smaller expendable launch vehicles or sounding rockets, require similar checkout and integration, but on a lesser scale.

Chapter 16: Government Services

NASA handles most payload processing and integration activities for launches at Kennedy Space Center. Payload processing and integration services also are provided at other major launch sites, including Wallops Flight Facility, Vandenberg Air Force Base and White Sands Missile Range.

NASA/Kennedy Space Center(KSC)

KSC is responsible for the management and direction of:

- Shuttle and NASA ELV launch preparation, integration and checkout
- Integration and checkout of payloads flying on these vehicles, including Spacelab, Space Station, upper stages and other attached or deployable payloads
- Shuttle launch and landing operations and NASA ELV operations
- Design, development, construction, operations and maintenance of launch, recovery and landing facilities and ground support equipment

NASA encourages commercial payload developers to contact the KSC payload organization for technical assistance early in the planning stages. This assistance is important in factoring ground operations considerations into payload design and support requirements planning.

Payload developers planning a launch on an ELV should communicate directly with the launch vehicle provider, who then will coordinate payload and vehicle support requirements with KSC. Developers planning a launch on the Shuttle, should contact Flight Requirements and Manifesting Management at NASA Headquarters, Office of Commercial Programs, 703-557-5328.

The KSC payload organization appoints a Launch Site Support Manager (LSSM) when a NASA-managed payload element is assigned to fly on either a Shuttle or an ELV. The LSSM produces the KSC Launch Site Support Plan (LSSP), which compiles the processing scenario, the payload test and support requirements, together with the KSC requirements on the payload, into one plan for payload launch and landing site activities.

The LSSM is the primary contact for project planning and provides support to the payload owner during the ground processing at KSC. In this capacity, the LSSM coordinates planning activity between the customer and supporting elements within KSC, NASA Headquarters and other NASA Centers. This coordination assures that payload requirements and operational plans are feasible with KSC and Agency capability and plans.

KSC has entered into agreements with three major commercial ELV operators, McDonnell Douglas, for the Delta; General Dynamics for the Atlas/Centaur; and Martin Marietta for the Titan.

Contact: JoAnn H. Morgan
Payload Projects Management
NASA/Kennedy Space Center
Mail Code CP-APO
Kennedy Space Center, FL 32899
(407) 867-3374

NASA/Wallops Flight Facility

Principal facilities on the Wallops launch range in Virginia are those required to process, checkout and launch solid rocket boosters carrying payloads on suborbital or Low Earth Orbit trajectories. Included are launch pads, launchers, blockhouses, booster preparation and payload checkout buildings, dynamic balance equipment, wind measuring devices, communications and control instrumentation, TV and optical tracking stations, surveillance and tracking radar units and other supporting facilities.

Wallops requires program interface with commercial developers for launching from its Wallops Island site.

The facility furnishes range operational planning, analytical feasibility and design studies; payload, vehicle and recovery system engineering; payloads construction and integration; test evaluation; and data analysis and reporting. Field support is provided as needed for launch operations.

Contact: Donald Friedman
NASA/Goddard Space Flight Center
Mail Code 702.0
Greenbelt, MD 20771
(301) 286-6242

Western Space and Missiles Center (Vandenberg)

NASA/Kennedy Space Center is responsible for the operation of the KSC Vandenberg Launch Site Resident Office in California. This office serves as the interface with the U.S. Air Force to arrange for base support for all NASA elements at Vandenberg. It supports spacecraft requirements of other NASA centers, commercial and government agencies not affiliated with DOD by providing operational and administrative support.

Contact: Robert Butterfield
NASA/Kennedy Space Center
Mail Code CP-APO
Kennedy Space Center, FL 32988
(407) 867-2217

White Sands Missile Range

Use of NASA-owned equipment and facilities are required for launches at White Sands in New Mexico. These include an assembly building and associated payload integration equipment. Approval from NASA, usually in the form of a Memorandum of Agreement (MOA), is required. Range support, including radar, telemetry, optical coverage, payload vibration, flight safety and other normally provided test range support and facilities, must be negotiated with the White Sands Missile Range.

Contact: U.S. Army White Sands Missile Range
Attention: STEWS-NR-PR
(Future Programs Team)
White Sands Missile Range, NM 88002
(505) 678-1134

Chapter 17: Commercial Services

Astrotech Space Operations (see below) is the only U.S. company that operates a commercial processing facility for large payloads.

Other companies offer payload processing as a third-party contractor, liaison or leasing agent. These firms can work with the commercial developer to design the experiment, the hardware and the planning scenario for launches on the Shuttle and on expendable launch vehicles.

Astrotech Space Operations, L.P.

Astrotech owns and operates the only U.S. commercial payload processing facility, located in Titusville, FL, adjacent to the Kennedy Space Center. Its capabilities include:

- Non-hazardous processing buildings; clean room high bay complexes (4);
- Hazardous processing building; clean room high bays (4)
- Payload storage building
- Customer office building
- Warehouse storage building (6,250 square ft)

Contact: George D. Baker
Astrotech Space Operations, L.P.
12510 Prosperity Drive
Silver Spring, MD 20904
(301) 622-5804, Fax (301) 622-2937

The Bionetics Corporation

The Bionetics Corporation provides life sciences payload development, integration and technical support for Shuttle middeck experiments, Spacelab racks and freeflyers; and ground support for animal, plant and cell biology experiments.

Services Include:

- Planning and schedules
- Complete documentation
- Hardware design
- Instrumentation
- Complete processing services
- Microbiological services

Contact: Chris Schatte
The Bionetics Corporation
2 Eaton St., Suite 1000
Hampton, VA 23669
(804) 722-0330

Eclipse Industries, Inc.

Eclipse Industries Inc. provides payload advance planning and microgravity testing on board the KC-135 aircraft.

Services include:

- Payload program and project evaluation, feasibility, testing
- Requirements
- Public affairs
- Staffing
- Resource planning
- Long-range forecasting

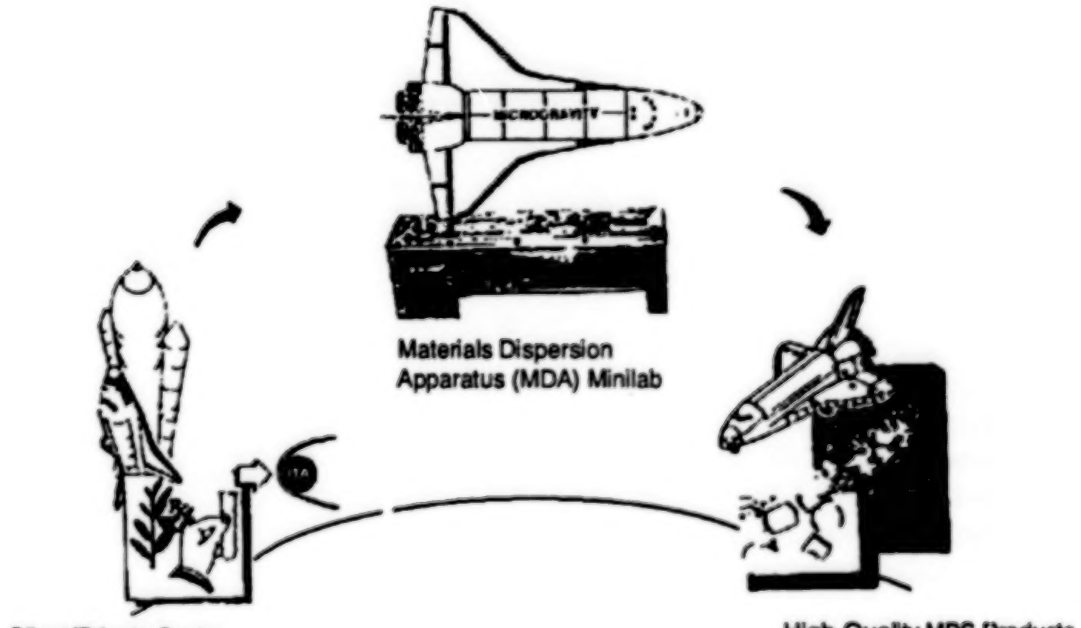
Contact: Rick Thienes
Eclipse Industries, Inc.
2719 W. Division St.
St. Cloud, MN 56301
(612) 259-4841, Fax (612) 654-8929

Instrumentation Technology Associates, Inc.

Turnkey access to space, generic experiment hardware payload integration, experiment carriers and payload integration for secondary payloads, including:

- Middeck lockers
- Get-Away-Special canisters
- Hitchhiker-M
- Hitchhiker-G
- OCP COMET recovery capsule
- Experiment apparatus containers
- Multi-Purpose Experiment Support Structure
- Experiment design validation includes a centrifuge to simulate Shuttle and ELV ascent and reentry

Contact: John M. Cassanto
Instrumentation Technology Assoc., Inc.
35 East Uwchlan Ave., Suite 300
Exton, PA 19341
(215) 363-8343, Fax (215) 363-8569



Integration, Assembly and Checkout Facility

This facility is adjacent to Ellington Field, Houston, and is near the NASA/Johnson Space Center and includes:

- Certified class 1,000 clean room
- High Bay integration area
- Bonded storage

Contact: Douglas S. Lilly
Space Industries, Inc.
711 W. Bay Area Blvd., Suite 320
Webster, TX 77598-4001
(713) 338-2676

Orbital Sciences Corporation

Orbital Sciences Corporation provides commercial space support services including commercial space operations licensing and coordination.

Mission Operations Services

- Mission planning and analysis studies
- Mission pre-launch and on-orbit operations
- Pre-launch ground operations
- Carrier aircraft flight operation

Payload Services

- Payload design and development
- Ground processing and logistics planning
- Payload integration
- Systems integration
- Spacecraft checkout

Range Services

- Range support planning and coordination
- Launch site selection
- Tracking and data reduction

Contact: Bruce A. Biehler
Orbital Sciences Corporation
12500 Fair Lakes Circle, Suite 350
Fairfax, VA 22033
(703) 631-3600

Orbital Systems, Ltd.

Aerospace engineering and consulting services include:

- Spacecraft system and system design and analysis
- Spacecraft integration with launch vehicles
- Launch vehicle assessment
- Environmental measuring systems
- Artificial intelligence
- Technical program management support

Contact: Roxanne B. Andrieux, Vice President for Computer Operations
Orbital Systems, Ltd.
1925 N. Lynn Street, Suite 301
Arlington, VA 22209
(703) 841-4394, Fax (703) 841-5196

Payload Systems Inc.

Payload Systems was founded in 1984 to provide science and engineering services to researchers undertaking experiments in space, ranging from Get-Away Specials (GAS), to middeck lockers to Spacelab programs. Project scientists and integration managers support payload design and development to assure that it meets all NASA safety and integration requirements and offers a valuable scientific return from space in a cost-effective manner. A typical Experiment Support team consists of a project scientist, project engineer and integration manager.

Services feature

- Payload integration and certification management for compliance with all NASA procedures and requirements, such as preparation and submission of all documents; project scheduling and budget; safety, acceptance and readiness reviews
- Experiment design to assure minimum scientific compromises due to Shuttle environment limitations such as power, weight, volume data storage and time
- Scientific expertise in materials processing, biomedical and human adaptation, large space structure and active control
- Crew training program to familiarize Shuttle crew with experiment operations
- Ground processing, flight support and post-analysis provided at Kennedy Space Center, Johnson Space Center and Edwards Air Force Base to accommodate all stages of flight

Contact: Michael D. Barg
Payload Systems Inc.
276 Third Street
Cambridge, MA 02142
(617) 868-8086, Fax (617) 868-6682

Space Hardware Optimization Technology, Inc. (SHOT)

This consulting engineering firm specializes in the design, fabrication and integration of spacecraft components and equipment. The firm has experience in life sciences and materials processing microgravity experiments. SHOT's engineers designed, fabricated and qualified flight hardware for the Shuttle.

Contact: John C. Vellinger, Vice President
Space Hardware Optimization Technology Inc., (SHOT)
P.O. Box 351
Floyd Knobs, IN 47119
(812) 923-9591

SPACETEC Ventures, Inc.

SPACETEC provides a unique approach to end-to-end space services which ensures in-depth technical and documentation support during feasibility, pre-flight, flight and post-flight phases of experiment development and implementation.

Capabilities

- Systems engineering support services
- Mission integration services
- Testing and evaluation support services
- Data analysis services
- Project management support services

Expertise

- Experiment feasibility analysis
- Experiment definition and development
- Mission integration, documentation and review assistance
- Systems checkout and verification
- Definition and implementation of physical integration requirements
- Mission planning and operations
- Recovery of experiment and data products

Contact: SPACETEC Ventures, Inc.
P.O. Drawer Y
Hampton, VA 23666
(804) 865-0900

SpaceTech, Inc.

A subsidiary of the Center for Space and Advanced Technology, SpaceTech is a science and engineering corporation specializing in development, analytical and physical integration, command and control, and data analysis of small payloads. The firm also offers associated training for users.

Contact: John R. Williams or Kim Ellsworth
SpaceTech Inc.
The James Burr House
58 Charles Town Road
Kearneysville, WV 25430
(304) 728-7288 or (703) 385-4355

Wyle Laboratories

Wyle offers a full range of payload engineering services, design, fabrication/assembly, testing, analysis, flight operations support, and program planning and control. The customer can enter anywhere in the process or contract for specific activities.

The firm also offers utilization and logistics support, as well as manifesting software. The software operates on Wyle's Space Station payload database which contains payload operational and logistics data throughout the 5 phases of a Space Station payload life cycle:

- Prelaunch ground operations
- Transfers-to-orbit
- On-orbit operations
- Transfer-from-orbit
- Post landing ground operations

Contact: Ronald E. Giuntini
Manager of Space Engineering
Wyle Laboratories
7800 Governors Drive West
Huntsville, AL 35807
(205) 837-4411

Section Six: Space Transportation

Routine, affordable, reliable access to space is the foundation on which many other commercial applications of space technology, such as for microgravity processing and remote sensing, are based. NASA operates the Shuttle, a reusable spacecraft that can launch satellites from its cargo bay, as well as carry payloads aboard the bay and the pressurized middeck area. Three major American transportation launch providers, McDonnell Douglas, Martin Marietta and General Dynamics, offer services for multi-stage vehicles that carry heavy payloads, such as communications satellites and other large payloads, into Low Earth Orbit and beyond. Other companies offer smaller vehicles and related support services. Still others, offer sounding rocket vehicles, launching payloads to near-space, but not in orbit.

There is a competitive international market that involves U.S. commercial launch-service providers and entities from a growing number of industrialized nations. In addition, support services and commercially operated spaceports are being planned in the United States and abroad.

Chapter 18: Regulations

Other than for the smaller capacity launch vehicles, alternatives to government ranges for launch operations do not exist at the present time – although several interest groups, notably Spaceport Florida and the states of Hawaii and Virginia, are moving in the direction of establishing private, commercial launch sites. Until that time, major launch service providers (e.g., McDonnell Douglas, General Dynamics, Martin Marietta) must abide by the Air Force's Model Range Use Agreement. This agreement sets forth the terms and conditions under which the Air Force will permit use of ranges, facilities and associated goods and services to commercial entities in support of production and/or launching of commercial expendable launch vehicles on a cost-reimbursable basis.

The major issues in these provisions include terms and conditions of the U.S. Government's ability to preempt commercial launches; defer establishment of firm prices for range use to subsequent agreements; and specify the degree of liability placed on the commercial launch service provider, subcontractors and customers.

Commercial space launch activities are defined to include launches, launch site operations and certain mission-related activities. In 1984, the Commercial Space Launch Act gave the Department of Transportation the authority to regulate these activities.

Licensing Procedures and Regulations

Launch service providers negotiate launch licenses through the U.S. Department of Transportation's Office of Commercial Space Transportation, which is responsible for licensing and regulating U.S. commercial space launch activities in a manner intended to protect both public safety and government interests, and to encourage the development of commercial launch capabilities. Among the regulatory functions of this office are:

- Development of Safety Requirements and Standards
- Financial Responsibility Requirements
- Review and Approval Criteria
- Monitoring Licensee Activities

Licensing procedures ensure the protection of interests stated explicitly in the Commercial Space Launch Act: public health and safety, the safety of property, and the national security and foreign policy interests of the United States.

The fundamental requirement is that the launch company proposing to conduct commercial space transportation activities demonstrate, through the application process, the capability to assure its operations will be conducted safely and responsibly. The Commercial Space Transportation Licensing Regulations (Final Rule 1988) constitutes the procedural framework for reviewing and authorizing all proposals for conducting commercial space transportation activities.

In order to encourage innovation, and recognizing the diversity of launch vehicles, missions and applicant circumstances, the Licensing Programs Division makes an effort to offer flexibility with regard to the form in which information may be submitted.

Assessment of a launch license application includes a Mission Review and a Safety Review. The Mission Review is general in nature and provides an early warning mechanism to identify policy questions that are germane to the application. The Safety Review is devoted to the applicant's operational capabilities, focusing on safety procedures and personnel equipment.

Licensing Procedures and Regulations (continued)

There are similar assessments of license applications for other commercial space activities, such as reentry operations. In conjunction with the two reviews, DOT sets insurance requirements for the launch or activity, as required by the Commercial Space Launch Act. Insurance requirements are based on a practical understanding of the elements comprising exposure, the factors affecting risks and a review of any failure history data.

Contact: Licensing Programs Division
U.S. Office of Commercial Space Transportation
Department of Transportation
400 Seventh Street SW
Washington, DC 20590
(202) 366-5770

Documentation

The commercial developer is referred to the following related documents for more in-depth information:

- Commercial Space Launch Act of 1984, 14 U.S.C. App. 2601
- Commercial Space Transportation Licensing Regulations, 14 CFR Part 400
- Requirements for Launch License Applications
- Requirements for Launch Site Operators License Applications
- Guidelines for Environmental Impact Statements for the Development of Commercial Space Launch Facilities

Chapter 19: Launch Ranges

At least ten countries and groups of countries have established facilities for space launches. The United States and the Soviet Union, member countries of the European Space Agency, Japan and China each have launch ranges to meet their particular range of launch requirements. Brazil has facilities for small capacity operations and is constructing new facilities to meet a wider range of requirements. Italy, India, Australia and Sweden also have facilities for small capacity launch operations. A number of these countries, as well as private entities, are studying the feasibility of establishing commercial space launch facilities to support the market of launch service providers worldwide.

Factors for consideration in selecting a launch site include: location, existing infrastructure and accessibility. Location is critical for economic and safety reasons. Regardless of whether the payload is intended for polar or equatorial orbit, the most efficient insertion is with a trajectory that requires little or no course correction. For equatorial orbits, the most practical launch is one that originates from the equator with an eastward trajectory, taking advantage of the Earth's rotation. Safety considerations restrict trajectories, though potentially optimal, over populated areas or regions of industry, agriculture or fishing activities.

Conducting launch operations requires a variety of services and facilities, such as a complete telecommunications system of tracking, telemetry and control; high-quality, high-output power supplies; integration and processing buildings; launch pads; and highly trained personnel.

There are two major range areas in the United States capable of supporting launch operations for the Delta, Atlas and Titan expendable launch vehicles (ELV's). Kennedy Space Center serves as the primary center within NASA for the test, checkout and launch of manned and unmanned space vehicles; it is the only launch site for the Shuttle. NASA and the Air Force have developed Model Range Use Agreements governing commercial use of other government-owned facilities such as Cape Canaveral Air Force Station in Florida and Vandenberg Air Force Base in California.

Small capacity ELVs have greater options for launch facilities. In addition to Cape Canaveral and Vandenberg, the NASA/Wallops Flight Facility in Virginia can accommodate sounding rockets and small orbital vehicles. Other ranges in the United States that can support sounding rockets include Barking Sands, HI; Eglin Air Force Base, FL; Greenriver, UT; Kwajalein, Marshall Islands; Tonapah, NV; White Sands, NM; and Poker Flat Research Range, AK. All of these are federally owned except for Poker Flat, which is owned by the University of Alaska.

There is considerable interest in the development of privately owned commercial launch facilities, notably Spaceport Florida at Cape Canaveral and/or Cape San Blas; Palima Point on the southeast coastline of the Island of Hawaii; and Wallops Island, VA. In 1990, plans were underway by the Spaceport Florida Authority to refurbish the Cape San Blas facility to accommodate a suborbital launch by the end of the year.

Global Launch Activity

Nation	Location	Latitude
United States	Kennedy Space Center, Cape Canaveral, FL	28.5° N
	Spaceport Florida (commercial site-under study)	28.5° N
	Vandenberg Air Force Base, CA	34.7° N
	Wallops Flight Facility, Wallops Island, VA	37.9° N
	Palima Point/Kahilipali Point, HI (under study)	19.0° N
Soviet Union	Baykonur Cosmodrome, Tyuratam	45.6° N
	Plesetsk	62.8° N
	Kapustin Yar	48.4° N
ESA/France	Guiana Space Center, Kourou, French Guiana	5.2° N
Italy	San Marco (platforms, off the coast of Kenya, Africa)	2.9° S
Sweden	Esrange, Kiruna	68.0° N
Japan	Tanegashima Space Center	30.4° N
	Kagoshima Space Center	31.2° N
	Hokkaido Space Center (under study)	0.0°
	Uchi Noura	—
China	Xi Chang, Sichuan Province	28.1° N
	Shuang-cheng Tzu (Jiquan), Gansu Province	40.6° N
	Jiuquan (west of Beijing)	—
	Hainan (under study)	—
Australia	Cape York, Queensland (under study)	11.0° N
	Woomera	31.1° S
India	Sriharikota Launching Range, Sriharikota Island	13.9° N
	Thumba Equatorial Rocket Launching Station	8.0° N
Brazil	Barraira Do Inferno	4.0° S
	Alcantara, St. Louis Bay	2.0° S
Canada	Churchill Research Range	—

Churchill Research Range

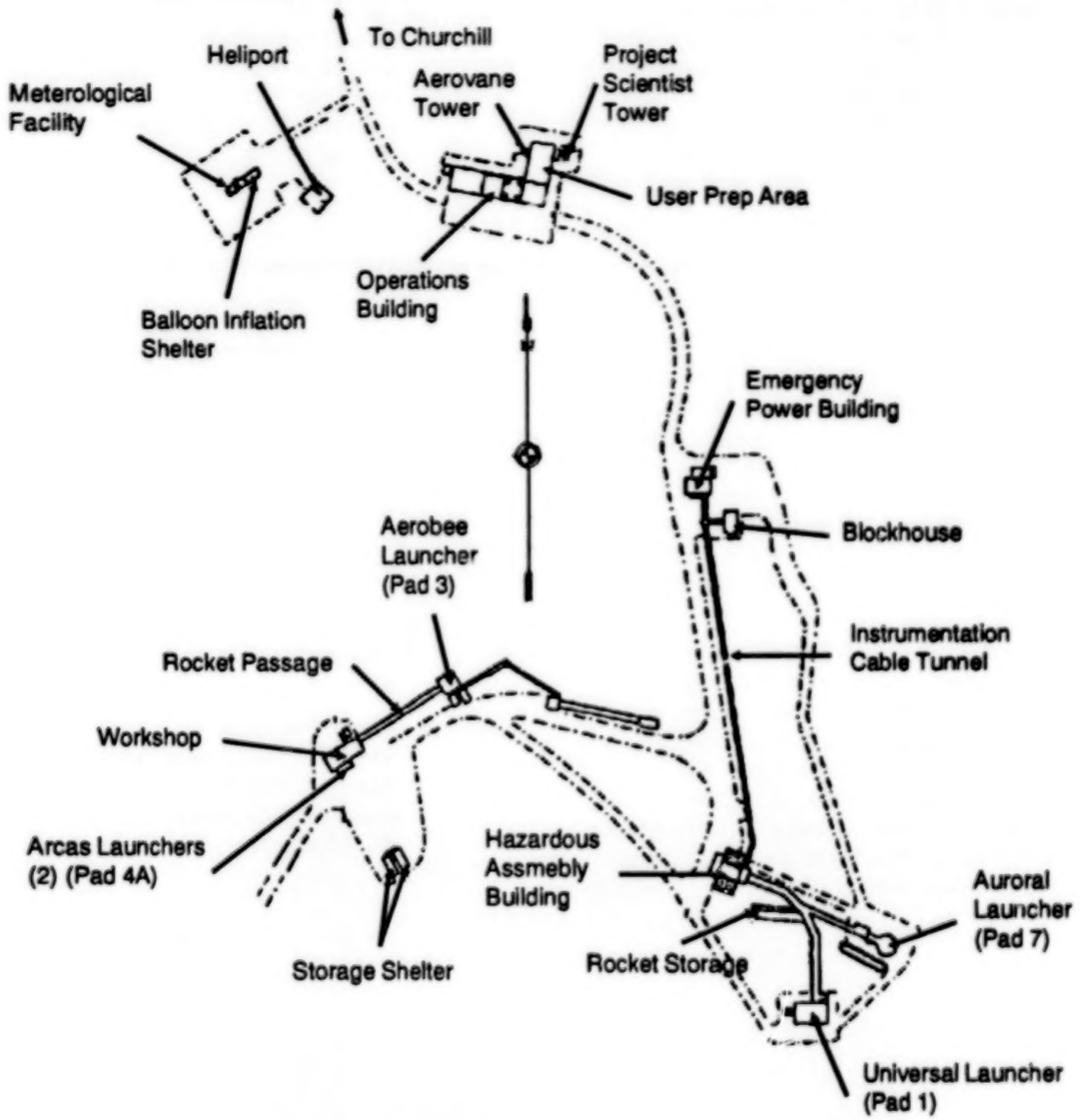
Churchill Research Range is located on the northeastern tip of Manitoba, Canada, with an impact area of back land and water extending 840 kilometers in an east-west direction and 800 kilometers in a north-south direction. The launch site includes four launch complexes, a hazardous assembly area, an explosive storage area, a blockhouse, an operations building and a meteorology building.

The rocket launching facilities include the Aerobee Tower, the Auroral Launcher, The Universal Launcher and an Arcas Launcher. The launch complexes share a common blockhouse which serves as the control center during launch operations. The operations building houses the telemetry, communications, tracking equipment, range user payload preparations area, administration offices, supply warehouse, motor vehicle workshop and an observation dome. An Auroral Observatory is located 13 km east of town to accommodate users' instruments for ground-based observations.

Facilities Include

- Launch site operations
- Launch in an auroral oval
- Excellent payload recovery
- Large impact area
- Temperature controlled launch bays
- Rocketry manufactured in Manitoba
- Shipping access by air, rail or sea

Contact: Les Tough, Manager
Aerospace Technology Program
430-155 Carlton Street
Winnipeg, Manitoba, Canada R3C 3H8
(204) 945-2030, Fax (204) 945-1354



NASA/Kennedy Space Center

Kennedy Space Center, immediately north and west of Cape Canaveral, is about 34 miles long and varies in width from 5 to 10 miles. The Center was created in the early 1960s to serve originally as the launch site for the Apollo lunar landing missions. After the Apollo program ended in 1972, KSC's Complex 39 was used for the launch of the Skylab spacecraft.

KSC is located at 28.5 degrees North Latitude. Because of their location on Florida's East Coast, the facilities at KSC permit a trajectory to equatorial and other low inclination orbits, entirely over the Atlantic Ocean. However, polar and other high inclination orbits are not practical from this location because of the costs that would be incurred in avoiding the land mass and population centers north or south of the Cape during insertion to orbit.

Today, KSC is responsible for the management and direction of the Shuttle and NASA's expendable launch vehicles (ELVs), including preparation, integration and checkout; integration and checkout of payloads flying on these vehicles, such as Spacelab, upper stages and other attached or deployable payloads, including commercial experiments; Shuttle launch and landing operations and NASA's ELV launch operations; and design, development, construction, operations and maintenance of launch, recovery and landing facilities and ground support equipment. The Center also conducts research programs in areas of life sciences related to human spaceflight. In the future, scientists and engineers at KSC will be responsible for the preflight and launch operations of the Space Station Freedom and will be involved in all phases of its logistics support activities.

The State of Florida has plans for developing a commercial spaceport at Cape Canaveral, adjacent to KSC (see page 195). The project includes refurbishing some of the launch sites that no longer are used by the Air Force or NASA. A commercial spaceport could support the entire range of U.S. commercial ELV's. It also could take advantage of the complete infrastructure, from payload processing facilities to down-range tracking equipment, already in place and operational, that is used to support NASA and Air Force space launch operations.

Contact: George Mosakowski
NASA/Kennedy Space Center
Mail Code PT-PMO
Kennedy Space Center, FL 32899
(407) 867-3494

NASA/Wallops Flight Facility

Wallops Flight Facility is one of the oldest launch sites in the world. Established in 1945, the facility manages and implements NASA's extensive sounding rocket projects, using suborbital rocket vehicles to accommodate about 50 scientific missions a year – almost half of all the rockets that are launched at Wallops. The first rocket, a Tiamat, was launched on July 4, 1945, and since that time about 13,000 rockets have been launched from Wallops Island.

Situated on the Delmarva Peninsula, on Virginia's coast, the Facility is located at 37.9 degrees North latitude. In addition to balloons and sounding rockets, Wallops also can support small orbital vehicles, such as LTV's Scout and SSI's Conestoga. The launch site includes five launch pads, two launch blockhouses and fifteen assembly bays. In addition to its launch capabilities, Wallops also plans and conducts Earth and ocean physics; ocean biological and atmospheric field experiments; satellite correlative measurements; and developmental projects for new remote sensor systems.

The state of Virginia has plans to develop a commercial launch site at Wallops Island, through its Center for Innovative Technology. The proposal would include refurbishing abandoned launch pads and/or constructing new ones to accommodate commercial scouts and smaller class ELVs. The project also considers refurbishment of an aircraft runway at Wallops to accommodate the Pegasus launch system.

Contact: Donald Friedman
NASA/Goddard Space Flight Center
Mail Code 702.0
Greenbelt, MD 20771
(301) 286-6242

Spaceport Florida

The concept of creating a commercial spaceport in Florida was developed by the Governor's Commission on Space in 1988. As a result, the Office of Space Programs was created within the Florida Department of Commerce. A feasibility study determined the Spaceport Florida concept to be financially, economically and operationally feasible.

The Spaceport Florida Authority was created by the 1989 Florida Legislature to develop commercial launch centers at deactivated Air Force launch sites at Cape Canaveral in Brevard County, and Cape San Blas in Gulf County. It also was charged with statewide responsibility for stimulating space-related industry, education, research and tourism development.

The Authority intends to attract high tech, space-related manufacturing industries and research and development projects to Florida by establishing the state as the premier location for access to space (commercial, NASA, military), and by extending other business incentives (sales-and-use tax exemptions, bonding capabilities, government support) to space-related industries.

Contact: Edward O'Connor, Executive Director
Spaceport Florida Authority/State of Florida
305 Cocoa Isles Boulevard, Suite 401
Cocoa Beach, FL 32931
(407) 868-6983

Western Space and Missile Center (Vandenberg)

The Western Space and Missiles Center (WSMC) is an operational component of the Air Force Space Command and is located at Vandenberg Air Force Base in Santa Barbara County, on the California central coast. Located at 34.7 degrees North Latitude, the Vandenberg launch facilities are used for polar and other high inclination orbits because the launches can be directed south or southwest, out over the Pacific Ocean.

As may be expected, programs of a wide variety are brought to WSMC, varying in magnitude from small, short-duration tests, to continuing programs involving developmental and operational testing of complex weapons systems. The requirement for assembly buildings, launch complexes and other technical support facilities at Vandenberg Air Force Base normally is presented to WSMC early in the planning stage. The Center provides support for programs that are approved and assigned, and attempts to meet user needs from the available inventory.

Commercial range users (i.e., non-DOD) should contact the responsible System Test Manager to determine the funding policy in effect for individual programs. The System Test Manager (STM) is the individual assigned to the Center through whom the user and the Test Center conduct business. The STM coordinates user requirements with other elements of WSMC, including test operations, comptroller, flight and ground safety, and performs a host of other functions in obtaining support for the program. The STM may provide assistance to the user in preparation of the Program Introduction, Program Requirements Document and other associated requirements documentation. Early initial contact with the WSMC should be established before any documents are generated or submitted.

Contact: Western Test Range
Directorate of Test Operations, WTR/DO
Vandenberg Air Force Base, CA 93437

White Sands Missile Range

White Sands Missile Range (WSMR) has the capability to launch suborbital sounding rocket vehicles. These are launched by, and using the facilities of, the Naval Ordnance Missile Test Station, (NOMTS) at WSMR. The NOMTS has the facilities and support capability to launch a variety of sounding rockets, such as the Black Brant V, Nike Black Brant V, Terrier Black Brant, Orion, Nike Orion, Taurus Orion and Aries, some of which may be suitable for commercial use.

The range, located in New Mexico, is approximately 100 miles long (north to south) by 40 miles wide (east to west), so the latitude and longitude represents a broad area. The launch facilities supporting the rockets listed above are at about 32 degrees, 25 min, 4 sec; 106 degrees, 19 min, 15 secs. The base of the launcher is at an altitude of some 4,000 feet.

Depending on the type of operation, approximately one launch every two weeks (25 or 30 per year) can be supported with current facilities and capabilities. The facility is very committed, with projected workload remaining stable. Launch support, or the use of launch facilities and equipment, must be negotiated separately with NOMTS and requires a Memorandum of Agreement (MOA) with the Naval Sea Systems Command. Availability of NOMTS facilities, equipment and services is dependent on projected workload. NASA/Johnson Space Center is responsible for the direction of operations at the White Sands Test Facility (WSTF), which is located on the western edge of the range. This facility supports the Shuttle propulsion system, power system and materials testing.

Three CONSORT missions were launched from White Sands in 1989-90, all part of a program of the Consortium for Materials Development in Space, a Center for the Commercial Development of Space at the University of Alabama in Huntsville. These commercial missions flew on Starfire rockets provided by Space Services, Inc., of Houston, TX.

Contact: U.S. Army White Sands Missile Range
Attention: STEWS-NR-PR
(Future Programs Team)
White Sands Missile Range, NM 88002
(505) 678-1134

Chapter 20: Launch Vehicles

The U.S. firms that provide expendable launch vehicle services include large, established government contractors and small entrepreneurial companies. They base their services on a variety of vehicles, ranging from existing rockets developed to meet U.S. Government requirements, to new ones being developed commercially, often with innovative technology and propulsion systems. In most cases, these companies sell space transportation services, rather than the hardware itself, so that title to the launch vehicle and associated hardware remains with the launch service provider. This chapter divides ELVs into orbital and suborbital capabilities. It also describes the Space Transportation System (Shuttle) and includes Reentry Vehicles and Orbital Transfer Vehicles.

Global Launch Activity

U.S. Launch Vehicles

Orbital		Suborbital	
Space Shuttle	NASA/Rockwell	Cygnus series	Conatec, Inc.
Titan series	Martin Marietta	Starfire	Space Services,Inc.
Delta II series	McDonnell Douglas	Javelin, Hydac, etc.	Orbital Sciences Corporation
Atlas series	General Dynamics		
Pegasus, Taurus	Orbital Sciences Corporation		
Scout series	LTV		
Conestoga series	Space Services, Inc.		
EPAC S-series	E'Prime		
Industrial Launch Vehicle	American Rocket Company		

Foreign Launch Vehicles

Orbital		Suborbital	
Ariane series	Arianespace (France)	Black Brant series	Bristol Aerospace (Canada)
H-2	Japan	Sonda	Brazil
Long March series	China	Condor	Argentina
Proton series, Soyuz	Soviet Union	MASER-1	Sweden
Energia, Buran Shuttle		Skylark series	Great Britain
SLV-3, ASLV	India		
Mariane	Sweden		

Suborbital Vehicles

High altitude, suborbital launch vehicles offer critical opportunities for scientific and industrial research into microgravity, astrophysics, plasma and solar physics. Several companies provide suborbital launch services of various capabilities, accommodating payloads from 300-1000 pounds to altitudes as high as about 100 miles. These vehicles are gaining in demand as microgravity research evolves and the need for testing increases. Sounding rockets can provide sustained microgravity levels of 10^{-4}g-10^{-5}g for periods of about 5-15 minutes, depending on the operational characteristics of the vehicle. Many payloads can be recovered by parachute.

Ballistic Sounding Rockets and Services

Orbital Sciences' suborbital launch products and services include suborbital vehicles and their principal subsystems, payloads carried by such vehicles, and related launch support installations and systems used in their assembly and operation. OSC offers customized vehicle and payload design, manufacturing and integration, launch and mission support, and tracking and recovery services, as well as construction and activation of launch pads and other infrastructure elements. It also designs and builds scientific experiments and other payloads for launch and deployment on its suborbital boosters.

OSC's Space Data Division has produced and launched over 600 suborbital vehicles in configurations weighing up to 70,000 pounds and reaching altitudes of up to 550 miles. Boosters and sounding rockets are frequently configured using combinations and/or multiples of Javelin, Hydac, Nike, Improved Honest John, Sergeant, Talos, Castor, Terrier, Malemute and Minuteman I second-stage motors. Both the Javelin and Hydac suborbital boosters are OSC commercially-developed motors. Standardized fins, interstages and other vehicle hardware have been developed for cost effectiveness and responsive delivery.

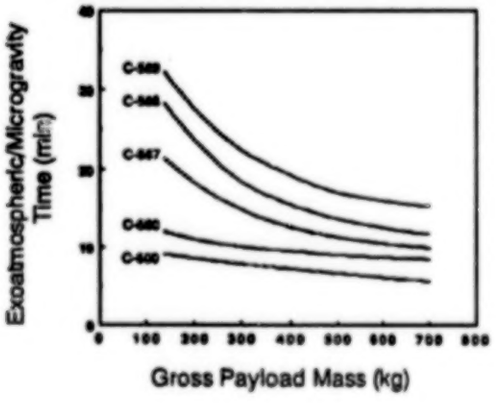
OSC also has established or supported suborbital rocket launch facilities at eleven locations including bases at South Point, HI; Kwajalein Atoll; Poker Flat, AK; Eglin AFB, FL; and Cape Cod, MA; as well as locations in Greenland, Indonesia, Puerto Rico and Brazil. It is installing two launch pad complexes (one at Wake Island in the Pacific and one at Cape Canaveral, FL) pursuant to launch of Starbird suborbital vehicles.

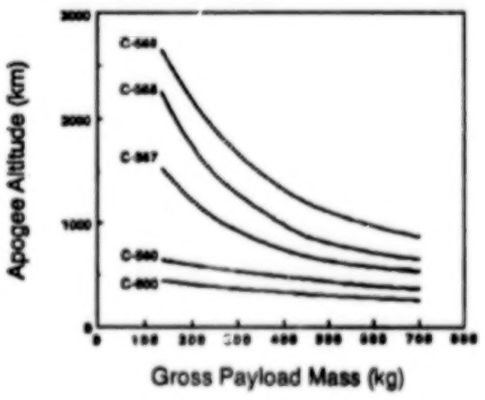
Available: Now

Contact: Scott Webster
Orbital Sciences Corporation
Space Data Division
3380 South Price Road
Chandler, AZ 85248
(602) 899-6000

Cygnus Series

The Cygnus series of suborbital launch vehicles is designed to accommodate typical research sounding rocket missions requirements while offering performance capabilities which exceed current operational sounding rocket systems. The Cygnus series consists of single-stage, two-stage and three-stage vehicle configurations employing solid propellant rocket motors. Performance in terms of experiment time versus payload mass, and apogee altitude versus payload mass are presented below.





Cygnus Series (continued)

The high reliability of the Cygnus series is based on the demonstrated reliability of a common stage motor (99.8% in over 570 flight applications), and augmented by the demonstrated reliability of the booster and upper stage motors (94 to 100% in 10 to over 100 flight applications respectively). The two-stage configuration (C-560) has a demonstrated reliability of 100% based on 20 flights.

The Cygnus vehicles are compatible with existing launchers and facilities at Wallops Flight Facility, White Sands Missile Range, Pacific Missile Range Facility, Poker Flat Research Range and Esrange. They also are compatible with range safety requirements at these ranges; i.e., three sigma dispersion areas within range boundaries and flight termination capability. Impact dispersions are contained within range safety acceptability, limited by use of a Boost Guidance System for two- and three-stage configurations, and the addition of a Guidance and Control System for three-stage configurations.

The Cygnus series employs a standard 31.0 inch diameter payload housing with an ogive and/or conical fairing. Accommodations for larger diameters (up to 40.00 inches) and small diameters (=17.26 inches) also are available. In addition, a full compliment of mission-unique support hardware is available, including telemetry systems, reentry/recovery systems, attitude and rate control systems and microgravity experiment modules.

Available: All systems are available for launch within 18 months of request.

Contact: Wayne H. Montag
CONATEC, Inc.
5900 Princess Garden Parkway, Suite 105
Lanham, MD 20706
(301) 552-1088

CYGNUS M-500

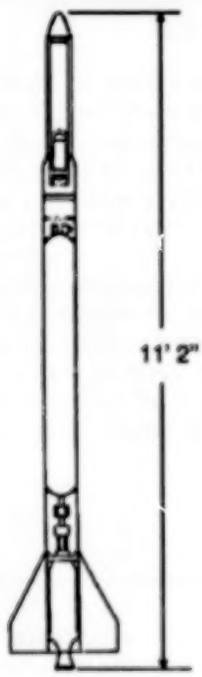
CYGNUS M-500 is a monopropellant rocket vehicle that incorporates light weight composite construction. The vehicle is provided as a compatible product with the SPACENESTS. A 500-pound thrust rocket motor will provide 30-40 seconds of propulsion for the CYGNUS/SPACENEST combination. Launch will be from a short mobile tower (production version), assisted by a solid fuel grain burned in the chamber prior to the ignition of the monopropellant. This integral solid grain concept is still experimental and may be replaced by a more conventional solid first stage booster.

Operational Characteristics

Dimensions:	134.0 in L, 6.5 in diameter
Weight:	40-45 lbs (empty)

Available: Now

Contact: Dean Oberg
Space Delivery Systems
P.O. Box 591
Buffalo, NY 14226
(716) 839-2158



SPACENEST-A

SPACENEST-A is a small, recoverable payload container. This near-space craft will be launched aboard a CYGNUS light-rocket to 40-50 mile altitudes. The craft will contain a standard-sized experiment rack (6 inches x 18 inches) which will have a variety of attachment and low voltage power supply options. The rack assembly will be provided to the client in advance. Experiment packages can be adapted to the rack and proprietary items added at the client's shop or laboratory. The rack is inserted into the container prior to the launch. Payload capacity using the CYGNUS launch vehicle will be 10 pounds.

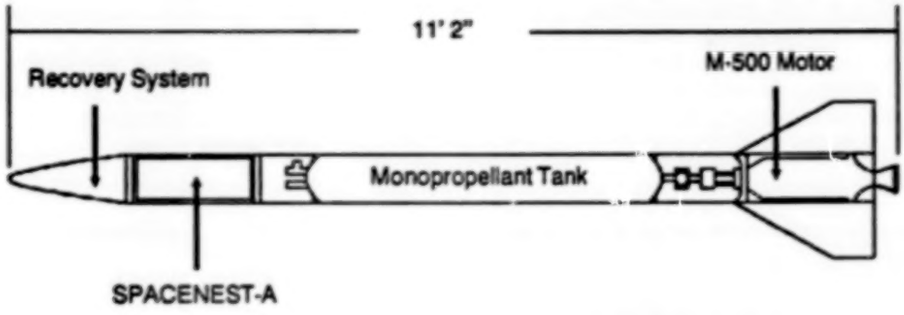
Operational Characteristics

Dimensions:	18.0 in L, 6.0 in diameter
Volume:	508.9 in^3
Weight:	10 lbs

Carrier: Cygnus Rocket

Available: 1991

Contact: Dean Oberg
Space Delivery Systems
P.O. Box 591
Buffalo, NY 14226
(716) 839-2158



SPACENEST-B

SPACENEST-B is a micro-spacecraft (4 in x 6 in) for launch to 150-200 miles. The micro-spacecraft also features a standard experiment rack, only smaller. It receives its initial boost via the CYGNUS MAX rocket with additional velocity imparted by a shaped charge or gas cannon mounted in the nose of the rocket. The mobility of the rocket-boosted-cannon (RBC) will provide flexibility not available with fixed base coil guns and cannons currently being proposed. Future enhancements to this system include the addition of four strap on boosters using the CYGNUS as a second stage and the SPACENEST-B cannon as the third stage. Orbital potential of this configuration is being assessed.

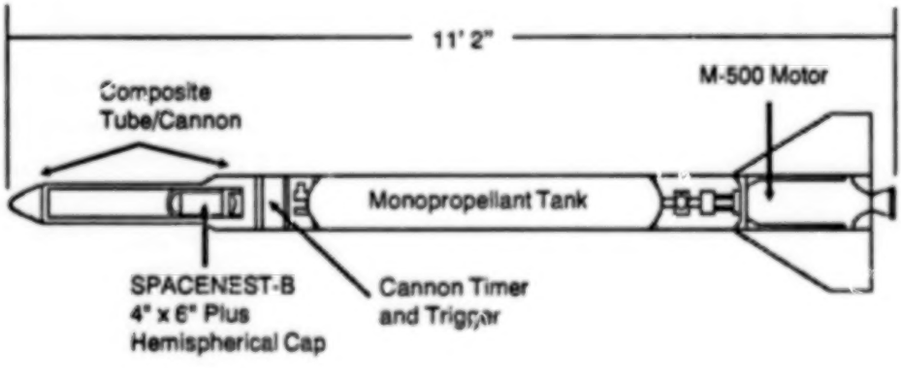
Operational Characteristics

Dimensions:	6.0 in Length, 4.0 in diameter
Volume:	75.4 cubic inches
Weight:	5-6 lbs

Carrier: CYGNUS MAX rocket

Available: 1992

Contact: Dean Oberg
Space Delivery Systems
P.O. Box 591
Buffalo, NY 14226
(716) 839-2158



The NASA Plan

To Award
Eight Percent
Of Prime And
Subcontracts
To Socially
And Economically
Disadvantaged
Businesses

NASA
National
Aeronautics and
Space
Administration

The NASA Plan

To Award Eight Percent Of Prime And Subcontracts To Socially And Economically Disadvantaged Businesses

1990

NP 136

NASA
National
Aeronautics and
Space
Administration

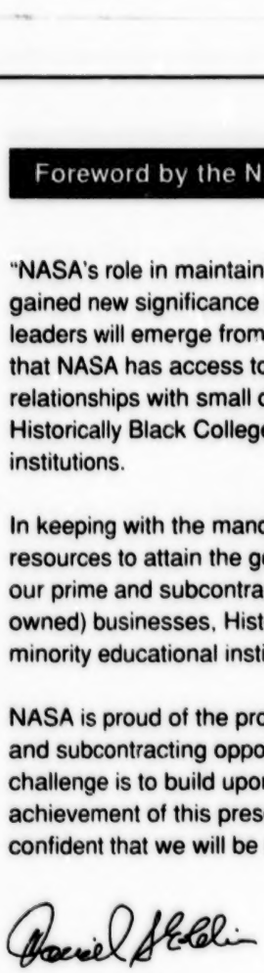
Table of Contents

Foreword by the NASA Administrator

"NASA's role in maintaining U.S. leadership in world aerospace activities has gained new significance as we approach the 21st century. Many of tomorrow's leaders will emerge from today's minority and female population. To ensure that NASA has access to this future talent pool, we must strengthen our relationships with small disadvantaged (including women-owned) businesses, Historically Black Colleges and Universities, and minority educational institutions.

In keeping with the mandate of Public Law 101-144, we will use all necessary resources to attain the goal of awarding eight (8) percent of the total value of our prime and subcontract awards to small disadvantaged (including women-owned) businesses, Historically Black Colleges and Universities, and minority educational institutions.

NASA is proud of the progress that has been made in providing contracting and subcontracting opportunities for small disadvantaged businesses. Our new challenge is to build upon these accomplishments and to work towards the achievement of this prescribed goal. I strongly support this effort, and I am confident that we will be successful."



Daniel S. Goldin

ORIGINAL PAGE
COLOR PHOTOGRAPH

I. Mission Statement

It is NASA's intent to provide small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions the maximum practicable opportunity to receive a fair proportion of NASA prime and subcontract awards

II. History

On November 9, 1989, President Bush signed the Department of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act for FY 1990 (P.L. 101-144). The legislation stated that:

> "The NASA Administrator shall annually establish a goal of at least 8 per centum of the total value of prime and subcontracts awarded in support of authorized programs, including the space station by the time operational status is obtained, which funds will be made available to small business concerns or other organizations owned or controlled by socially and economically disadvantaged individuals (within the meaning of section 8(a) (5) and (6) of the Small Business Act (15 U.S.C. 637(a) (5) (6)), including Historically Black Colleges and Universities and minority educational institutions (as defined by the Secretary of Education pursuant to the General Education Provisions Act (20 U.S.C. 1221 et seq.))."

The legislation continued:

> "To facilitate progress in reaching this goal, the NASA Administrator shall submit within one year from enactment of this Act a plan describing the process to be followed to achieve the prescribed level of participation in the shortest practicable time."

As part of the FY 1991 VA-HUD-Independent Agencies Appropriations bill (P.L. 101-507), in order to clarify their intent with respect to women-owned businesses, and for other reasons, the Committees included a modified provision as follows:

> "The NASA Administrator shall, to the fullest extent possible, ensure that at least 8 per centum of Federal funding for prime and subcontracts awarded in support of authorized programs, including the space station by the time operational status is obtained, be made available to business concerns or other organizations owned or controlled by socially and economically disadvantaged individuals (within the meaning of section 8(a) (5) and (6) of the Small Business Act (15 U.S.C. 637(a) (5) and (6)), including Historically Black Colleges and Universities. For purposes of this

section, economically and socially disadvantaged individuals shall be deemed to include women."

III. Responsibility

NASA believes that with the support and cooperation of the entire NASA Team, the integration of socioeconomic objectives within our program requirements has already made considerable progress and can lead to the continued success of each. At the direction of the NASA Administrator, the NASA Associate and Assistant Administrators, Center Directors, managing scientists and engineers, and their support staff are responsible for implementation of these goals.

General oversight of NASA's Small Disadvantaged Business Program rests with the NASA Deputy Administrator. The NASA Office of Small and Disadvantaged Business Utilization has been assigned the responsibility for development and management of NASA programs to assist small businesses, as well as firms which are owned and controlled by socially and economically disadvantaged individuals including women-owned businesses. This office functionally oversees and directs the activities of corresponding offices at each NASA installation.

The NASA Office of Small and Disadvantaged Business Utilization works collaboratively with the Office of Equal Opportunity Programs to ensure the participation of Historically Black Colleges and Universities and minority educational institutions. This process includes collaboration between the respective functional entities of equal opportunity, minority universities, and small disadvantaged businesses at each NASA installation.

IV. Outreach

In an effort to achieve the 8 percent goal, NASA plans to maximize its outreach to the minority business community by implementing new initiatives as well as by vigorously continuing to support ongoing efforts.

Plans will be developed to work with minority advocacy associations and organizations to promote more extensive contracting with small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions. NASA will inform the representatives of these organizations regarding this goal, the mutual efforts required to achieve it, and encourage their participation.

The NASA Office of Small and Disadvantaged Business Utilization will prepare and host industry briefings for executive officers of small disadvantaged businesses, including women-

owned, Historically Black Colleges and Universities and minority educational institutions. These meetings will provide senior NASA managers with opportunities to brief the participating executives on major NASA programs, as reflected in NASA's budget, and to invite their participation in the Agency's efforts.

NASA Headquarters will prepare and host briefings with the executive officers of NASA's major large business contractors to educate and to encourage major business contractors to subcontract with small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions.

NASA will encourage prime contractors to establish "mentor" relationships with small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions. NASA will develop and distribute a documentary film describing the NASA small disadvantaged business program.

NASA will publicize more widely to small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions, the recently-installed NASA toll-free number (1-800-2NASA95) for firms to obtain advice and counseling from the NASA Office of Small and Disadvantaged Business Utilization. NASA will utilize public broadcasting and electronic communication services for disseminating procurement information.

In addition to participating in congressionally-sponsored procurement conferences, the NASA center(s) will sponsor center-specific small disadvantaged business and minority educational institution conferences.

During FY 1991 the following outreach milestones are established:

- Sponsor a major conference during the second quarter. Purpose of the conference is to improve knowledge and skills of small disadvantaged businesses to enable them to participate more fully in the federal government and prime contractor marketplace.

- Coordinate with selected prime aerospace contractors to establish "mentor" relationships with small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions during the third quarter.

- Conduct workshops with groups of minority vendor associations.

- Sponsor a Women-Owned Business Conference during third quarter in the Washington area.

- Conduct a socioeconomic training course for NASA top and middle management personnel during the third and fourth quarters.

V. Policy

In order to successfully implement this plan, the following key policies will be adhered to:

a. Contract Consolidation. Requirements may be consolidated for the purposes of increasing program efficiency, economy or accountability. However, a wide base of potential suppliers for NASA's requirements is essential. With these considerations in mind, prior to effecting a contract consolidation valued at $5 million or more, including options, which will not be exclusively reserved for small or 8(a) firms, an impact assessment on the effects of consolidation on their present and future NASA small disadvantaged business shall be prepared by the center and approved by the cognizant Associate or Assistant Administrator.

b. Use of 8(a) contractors. Requirements-generating and procurement personnel shall work closely with NASA Small Business Specialists and the U.S. Small Business Administration to identify requirements appropriate for performance by 8(a) firms and other small disadvantaged firms capable of successfully performing them. Initial consideration shall be given to 8(a) firms for requirements which are follow-ons to existing 8(a) contracts.

c. Use of Historically Black Colleges and Universities and minority educational institutions. Program Offices, project offices, University Affairs Offices, and other relevant offices shall work closely with the Assistant Administrator for Equal Opportunity Programs and the Director of Minority University Research and Education Programs, and NASA installation counterparts to ensure awareness of and substantial participation of minority educational institutions in NASA's research and educational contracts and grants.

VI. Acquisition Strategies

In setting acquisition strategy, it is important to recognize the tools available to contract managers at both the prime and subcontract level. Currently, use of the Section 8(a) program is NASA's only method of sole source awards to developing small disadvantaged businesses. Conversely, a small disadvantaged business set-aside program, separate and distinct from the Section 8(a) program, will enhance NASA's ability to increase small disadvantaged business awards by expanding set-aside opportunities to all small disadvantaged businesses, notwithstanding those who are 8(a) certified. NASA will develop special initiatives to strengthen the small disadvantaged business program both in the direct awards area, which includes Section 8(a) contracting, and in the subcontracting areas under relevant NASA prime contracts. NASA Centers differ significantly in their missions, and their contracting varies accordingly.

Therefore, small disadvantaged business program strengthening may appropriately require different approaches by the centers. The following list shows some of the program improvement techniques which may be used, following approval of the plan.

- Use of senior management oversight committees at the centers for development and implementation of the small disadvantaged business program (Small and Small Disadvantaged Business Program Councils).

- Reinforcement of the Agency's outreach effort by issuance of small disadvantaged business program endorsements by field center management. Both internal and external audiences will be made aware of the higher goal established for NASA and of the importance of striving for its attainment.

- NASA policy statement in Request For Proposals and Sealed Bids stating NASA's intent to achieve a minimum of 8 percent of dollars to small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions .

- Inclusion of a contract clause encouraging prime contractors to use small disadvantaged business set-asides and to include small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions in teaming arrangements.

- Inclusion of small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions subcontracting plans in selection criteria for relevant Source Evaluation Board procurements.

- Assurance that Contracting Officers negotiate challenging goals and document the reasonableness thereof.

- Inclusion of past small disadvantaged business subcontracting accomplishments in the award fee determination process with consideration to additional emphasis given to small disadvantaged businesses, including women-owned, Historically Black Colleges and Universities and minority educational institutions subcontracting.

- Assurance that contractor Make-or-Buy Plans are reviewed for small disadvantaged business subcontracting.

- Collection of small and small disadvantaged business subcontracting data at the NASA center level.

- Accomplishment of effective contract and subcontract administration to assure:

  - Timely revision of subcontracting plans where changes or new work affect subcontracting opportunities;

  - Flow down of appropriate small disadvantaged business, including women-owned, Histori cally Black College and University,

and minority educational institution program responsibilities to subcontractors and assure compliance.

VII. Goals

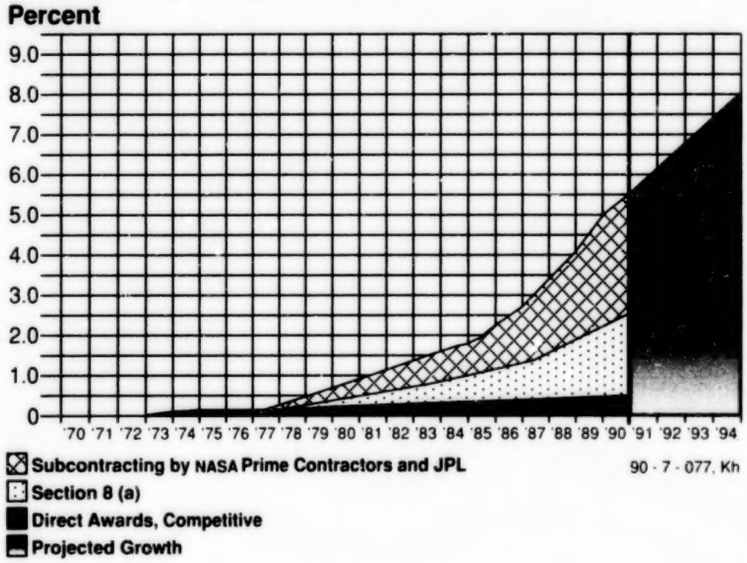
Annually, NASA will establish socioeconomic procurement goals including small disadvantaged business goals, with a target of reaching the eight percent level by the end of FY 1994. The NASA Associate Administrators, who are responsible for the programs at the various NASA Centers, will be held accountable for full implementation of the socioeconomic procurement plans.

Appropriate management performance plans and performance appraisals will include plans and goals accomplishments.

The chart below depicts NASA's history, from FY 1970 through FY 1990, of contract performance with small disadvantaged businesses since inception of the program in the Agency. The NASA Deputy Administrator has established FY 1994 as the target year for NASA to reach the legislatively mandated 8 percent goal. The chart also shows the projected milestones percent goal as follows:

FY 1991	6.1%
FY 1992	6.7%
FY 1993	7.5%
FY 1994	8.0%

Disadvantaged Awards (Obligations)
Office of Small and Disadvantaged Business Utilization
FY 1970 - 1994 — Percent of Awards



Progress toward achievement of these goals will be measured at the midpoint and end of each year and will be evaluated by the Administrator and Deputy Administrator.

VIII. Training

Training shall be provided to encompass three areas: NASA personnel, Historically Black Colleges and Universities and minority educational institutions and prime contractors. The NASA Office of Small and Disadvantaged Business Utilization shall develop an appropriate training package.

Installation personnel will be trained relative to the contents of this plan. Detailed training shall be provided to procurement personnel, requirements generating technical personnel, and to Equal Opportunity and Minority University Officers as well.

Each installation shall conduct a briefing/training session for on or near-site contractors. Headquarters shall also provide a copy of the training plan to all NASA prime contractors.

NASA shall provide briefing/training sessions as a part of NASA sponsored High Tech Conferences and other conferences as appropriate. The Agency managers of the Historically Black Colleges and Universities and minority university programs will provide information and/or a briefing to Historically Black Colleges and Universities and minority educational institutions, and work collaboratively with the Director, Office of Small and Disadvantaged Business Utilization to ensure maximum participation of those institutions.

IX. Reporting

Data pertaining to agency performance against the goals established under this program will be collected, evaluated, and reported by the Office of Small and Disadvantaged Business Utilization to the NASA Administrator, to NASA Program Offices, to NASA Centers and Congress, as appropriate.

Data on prime contracts, including Small Business Innovation Research awards, women business awards, minority university awards, and subcontract awards will be reported under this program.

X. Resources

The Director, Office of Small and Disadvantaged Business Utilization is responsible for the day to day management and development of NASA's programs to assist small disadvantaged businesses.

As defined in Public Law 95-507, a Small Business Specialist at each installation functionally supports and reports to the Director, Office of Small and Disadvantaged Business Utilization on matters related to small business, small disadvantaged business, women-owned business, and labor surplus. In addition, supporting procurement analysts, secretaries, and clerical staff at each installation are available to lend assistance to programmatic small disadvantaged business activities.

XI. Definitions

1. **Small Business**
   a concern organized for profit, independently owned and operated and not dominant in its field of operation.

2. **Small Disadvantaged Business**
   a small business concern owned and controlled by socially and economically disadvantaged individuals -

   (i) which is at least 51 per centum owned by one or more socially and economically disadvantaged individuals; or in the case of any publicly owned business, at least 51 per centum of the stock of which is owned by one or more socially and economically disadvantaged individuals; and

   (ii) whose management and daily business operations are controlled by one or more of such individuals.

3. **Socially Disadvantaged**
   Business owners who are members of a group subjected to historical bias: Black Americans; Hispanic Americans; Native Americans; Asian-Indian Americans; Asian-Pacific Americans; and other special cases as defined in PL95-507.

4. **Economically Disadvantaged**
   Business owners who are socially disadvantaged with diminished capital and credit opportunities.

5. **Historically Black Colleges and Universities and Minority Educational Institutions**
   Colleges and universities which are officially recognized as such by law, Presidential Executive Orders, or Federal regulation, and/or which serve or have substantial student populations from the socially and economically disadvantaged groups (i.e., Black, Hispanic, Native, and Asian Pacific Island Americans).

6. **Women-Owned Businesses**
   For the purposes of implementing Public Law 101-144, women-owned businesses are deemed socially and economically disadvantaged.

7. **Consolidated Contract**
A consolidated contract is one in which requirements previously procured under separate contracts or performed in-house are combined into larger dollar value contracts to be performed by a single contractor. Frequently, these consolidated contracts are for a longer term than the contracts which are being "consolidated".

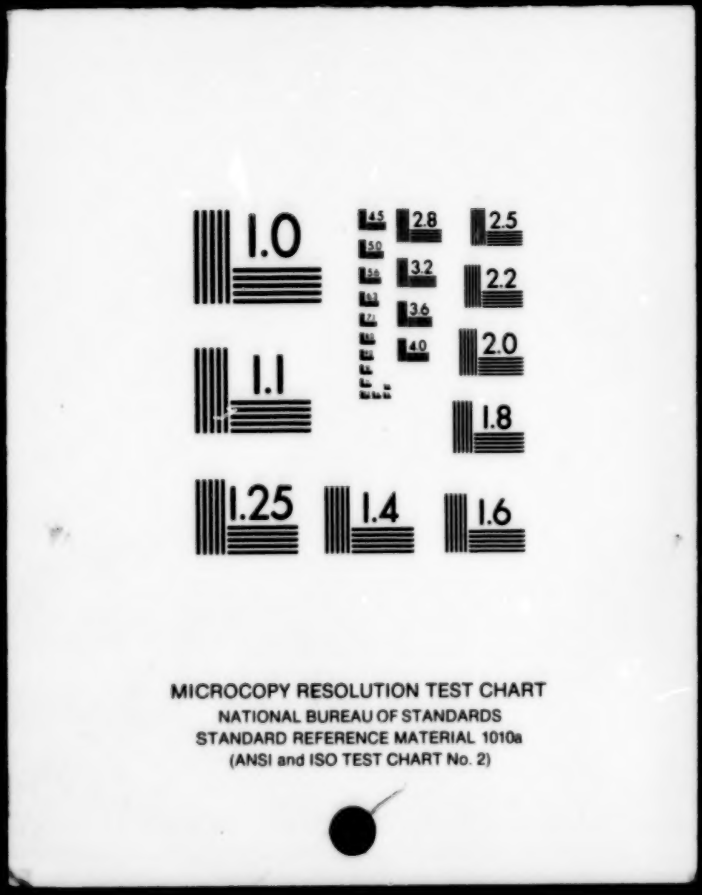
8. **Socioeconomic Procurement Goals**
Section 221 of Public Law 95-507 requires the head of each Federal agency, after consultation with the Small Business Administration, to establish realistic goals for the award of contracts to small business concerns and to small business concerns owned and controlled by socially and economically disadvantaged individuals.

END

DATE

FILMED

APR 15 1993



Starfire Sounding Rockets

The Starfire series is a family of suborbital sounding rockets for microgravity or other scientific payloads. The Starfire I, IA, IV and V are based on various configurations employing TX 664-4 (Terrier upgrade) first stages and Black Brant 5 or Patriot second stages. The Starfire II and III employ a Castor IVB solid core motor with two Castor strap-ons for the Starfire III (the latter configuration is similar to the Conestoga 210 without an orbital insertion motor). These configurations offer a wide range of payload weight and microgravity time (up to 7,000 lbs for up to 20 minutes). Three Starfire I rockets were launched for the University of Alabama/Huntsville (the CONSORT program) as of July 1990. Space Services also has an agreement with NASA for launch from Wallops Island.

Operating Characteristics

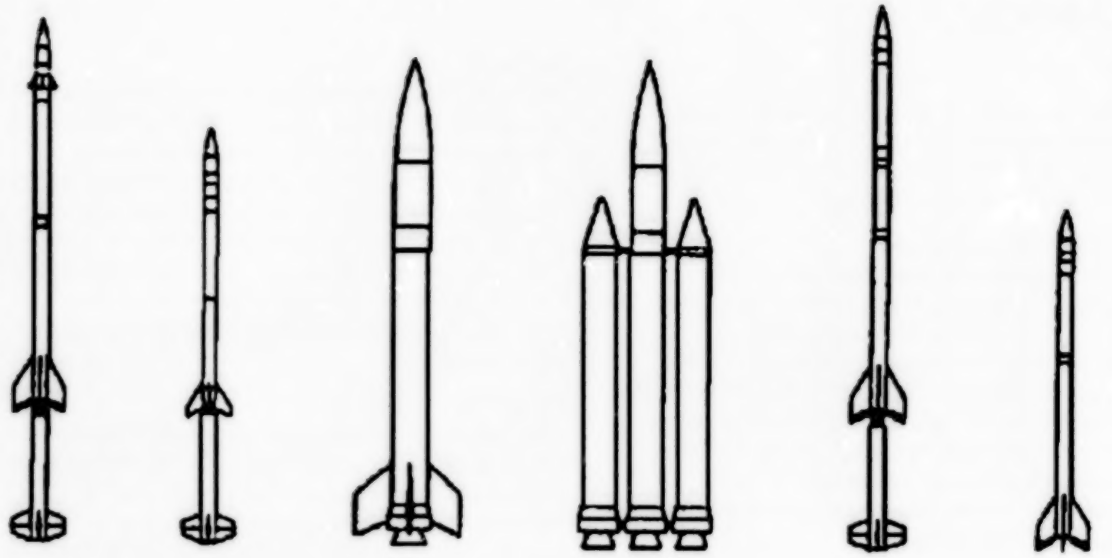
System height:	32 ft to 54 ft
Weight:	3,688 lbs to 82,000 lbs

Guidance: various, active boost guidance and spin stabilization; larger vehicles have thrust control

Payload Envelope: various, depending on configuration

Available: Now

Contact: Richard W. Scott, Jr.
Space Services Incorporated of America
7015 Gulf Freeway, Suite 140
Houston, TX 77087
(713) 649-1716, Fax (713) 649-3445



Starfire I | Starfire IA | Starfire II | Starfire III | Starfire IV | Starfire V

Starfire Sounding Rockets

Orbital Vehicles

Large capacity expendable launch vehicles (ELVs) are used for transporting satellites for communications, navigation, remote sensing and meteorology; facilities for materials processing, planetary missions and other scientific activities; and other types of spacecraft. Smaller ELVs carry research payloads, remote sensing and Low Earth Orbit (LEO) communications satellites.

The larger ELVs can lift payloads weighing more than 44,000 pounds to LEO, a circular orbit about 100-500 miles above the Earth. When ELV boosters are combined with upper stage motors, they can lift payloads weighing more than 11,000 pounds to Geosynchronous Transfer Orbit (GTO). GTO is a highly elliptical orbit required for placing communications satellites into their final position in Geostationary Orbit (GEO). GEO is a circular orbit at an altitude of 22,300 miles that allows a satellite to appear stationary at the same location over the Earth at all times.

As with many of the larger ELVs, the smaller class of ELVs often uses various configurations of the same vehicle design to accommodate payload requirements of weight and location. These vehicles generally can carry from 300 to 4,000 pounds to LEO and about 300-1200 pounds to GEO.

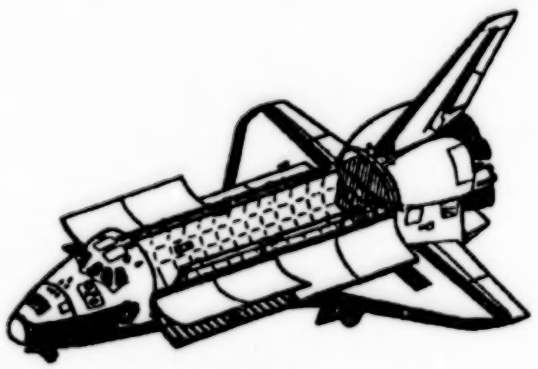
The Shuttle is an orbital vehicle that is reusable (hence, not an expendable vehicle). It is capable of accommodating not only humans, but also payloads that are large and small in both size (up to nearly 45 feet long, 15 feet wide) and weight (up to 55,000 pounds). The Shuttle is capable of traveling only to LEO (usually about 200 miles).

Space Shuttle

Orbiter

About the same size as a DC-9 aircraft (122.2 feet long, 78 feet wide at wing tips), the Shuttle contains the pressurized crew compartment, the unpressurized cargo bay and three main engines.

Orbiter Crew Compartment
The Orbiter pressurized crew compartment is comprised of three main areas, two of which are on an upper level called the flight deck. The Commander and Pilot's seats (stations) are in the forward part of the flight deck and look out the forward windshields. The aft flight deck (AFD) is the station for controlling and viewing orbital operations. The AFD is also the seat location for two mission specialists, and the two interdeck hatches that lead to the lower level ("the middeck").



Middeck
The middeck houses the one-to-three seats needed for the balance of the crew, the side hatch for crew entrance/exit, and the airlock for extravehicular activities. The middeck also houses Orbiter avionics and galley equipment, the waste management system, sleeping equipment, and lockers containing food, supplies, and other mission support equipment. Lockers (or their spaces) not needed for such purposes may be available for equipment to support experiments.

Cargo Bay
The Shuttle's unpressurized cargo bay is adaptable to hundreds of tasks. Large enough to accommodate a school bus (60 x 15 feet), the bay area carries satellites, spacecraft and pressurized Spacelab scientific laboratories to and from Low Earth Orbit. A wide range of equipment, described elsewhere in this catalogue, has been developed to accommodate flight activity in the cargo bay.

Remote Manipulator System
Mounted on the port side of the cargo bay is the remote manipulator system (RMS), developed and funded by the Canadian government. The RMS is a robot arm and hand with three joints analogous to those of the human shoulder, elbow and wrist. Two TV cameras mounted near its elbow and wrist provide visual ques to the crew member who operates it from the aft station of the flight deck. The RMS is about 50 feet in length and can move anything from satellites to astronauts to-and-from the cargo bay or to different points in nearby space, often deploying or retrieving satellites.

Space Shuttle (continued)

Thermal Protection System
Thermal tile insulation and blankets (known as the thermal protection system or TPS) covers the underside, bottom of the wings and other heat-bearing surfaces of the Shuttle and protects it during its reentry into the Earth's atmosphere. Some 24,000 individual tiles – no two alike – are installed by hand and are designed for reuse for 100 missions. The basic material of the tiles is pure-sand silicate fibers, mixed with a ceramic binder (see page 223).

Main Engines
The three main engines are clustered at the aft end of the Shuttle and have a combined thrust of nearly 1.2 million pounds at sea level. The high-performance, liquid-propellant rocket engines have a variable thrust ranging from 65 to 109 percent of their rated power level. The engines are 14 feet long and 8 feet in diameter at the nozzle exit. Designed for seven-and-a-half hours of operation, the engines fire for only eight minutes for each flight to orbit. As a result, the engines are expected to operate for 55 flights.

Orbital Maneuvering System
Once the main engines shut down as the Shuttle approaches orbital insertion, another propulsion system takes over. Two orbital maneuvering system (OMS) engines, mounted on either side of the aft fuselage, provide thrust for major orbital changes. For more exacting motions, the reaction control system comprising of 44 small rocket engines, clustered on the Orbiter's nose and on either side of the tail, are used in orbit.

External Tank

The external tank (ET), 154 feet long and 27.5 feet in diameter, is the largest single component of the Shuttle. In separate pressurized tank sections inside, the ET holds the liquid hydrogen fuel and liquid oxygen oxidizer for the Shuttle's main engines. During launch, the ET feeds the propellants under pressure through 17-inch ducts which branch off into smaller lines that feed directly into the main engines. Some 64,000 gallons of propellants are consumed by the main engines each minute. The tank also acts as a backbone for the Shuttle and the solid rocket boosters to which it is attached.

After orbital insertion, the external tank is jettisoned from the Shuttle. The discarded tank reaches 99 percent of orbital velocity and remains in space for up to an hour before it falls, re-enters the atmosphere and disintegrates. Machined from aluminum alloys, the ET is the only part of the system that is not currently reused.

In June 1988, NASA asked the private sector for expressions of interest in commercial and academic approaches for the use of ET's. Two organizations, GLOBAL OUTPOST, Inc. of Alexandria, VA (see page 170) and the Space Phoenix Program of Boulder, CO (see page 172), have signed separate agreements with NASA for the proposed use of expended ET's in orbit.

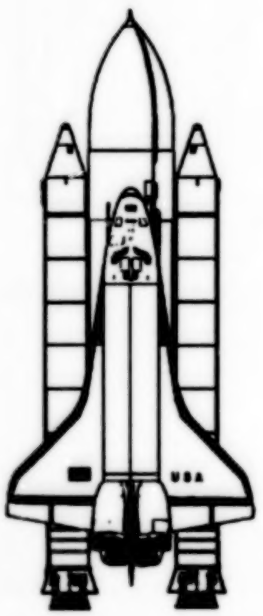
Solid Rocket Boosters

The Shuttle's two solid rocket boosters, designed for refurbishment and reuse, are the largest solids ever built (149.16 feet long, 12.16 feet in diameter) and the first to be flown on a manned spacecraft. Together, they provide the majority of thrust (5.8 million pounds) for the first two minutes of flight.

The solid propellant mix is composed of 16 percent aluminum powder (fuel) and almost 70 percent ammonium perchlorate (oxidizer), with the remainder consisting of a binder, a curing agent and a small amount of catalyst. A small rocket motor in each booster ignites the propellant at launch. During flight, the solid booster nozzles swivel up to 6 degrees, redirecting the thrust and steering the Shuttle toward orbit.

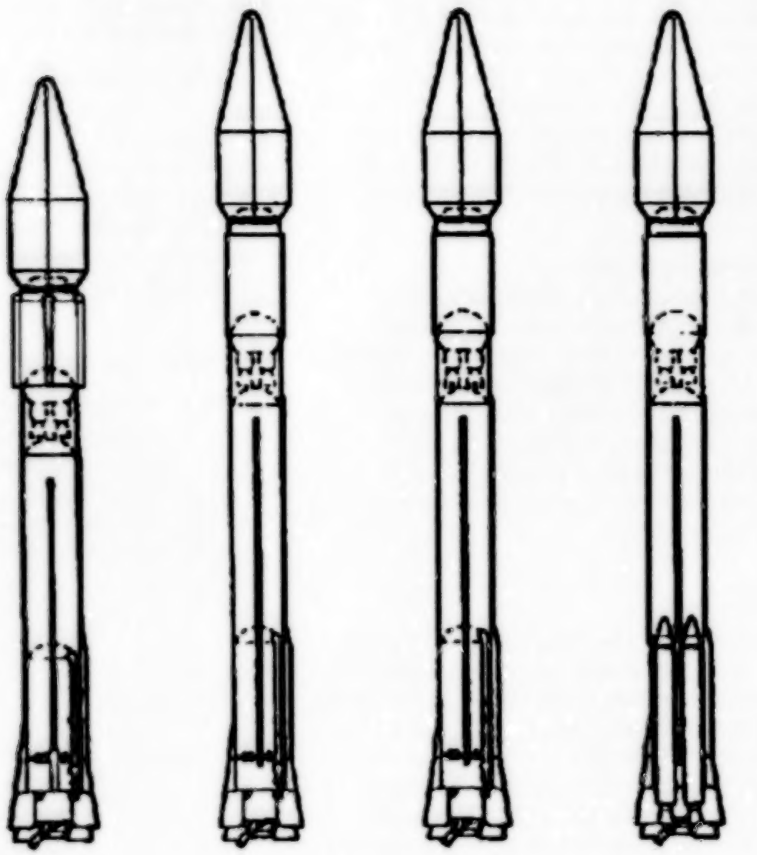
Available: Now operating with advanced scheduling

Contact: Richard N. Martucci
Customer Services Manager
Office of Space Flight
NASA Headquarters/Code MCI
Washington DC 20546
(202) 453-1921



ATLAS

The Atlas/Centaur, which is a combination booster and upper stage configuration, can carry up to 13,500 pounds in Low Earth Orbit (LEO) and over 5,000 pounds in Geostationary Transfer Orbit (GTO). An improved version of this vehicle is being developed to deliver 6,400 pounds to GTO. The Atlas is powered by a first-stage liquid engine burning kerosene (RP-1) and a second stage liquid hydrogen/liquid oxygen Centaur engine. Solid motor strap-on boosters provide extra lift. The first commercial Atlas launch carried a NASA scientific payload, the Combined Release and Radiation Effects Satellite (CRRES), in 1990.



ATLAS I ATLAS II ATLAS IIA ATLAS IIAS

Atlas (continued)

Atlas Launch Vehicle Specification Table

	Atlas I	Atlas II	Atlas IIA	Atlas IIAS
Overall Vehicle				
Length (Medium Fairing)	42.0 m/138 ft	45.6 m/150 ft	45.6 m/150 ft	45.6 m/150 ft
Length (Large Fairing)	43.9 m/144 ft	47.5 m/156 ft	47.5 m/156 ft	47.5 m/156 ft
Diameter	3.1 m/10 ft	3.1 m/10 ft	3.1 m/10 ft	
Gross Lift Off Weight				
(Med. Fairing)	163,900 kg/	187,170 kg/	187,310 kg/	233,600 kg/
	361,300 lbs	413,500 lbs	413,800 lbs	515,900 lbs
(Large Fairing)	164,290 kg/	187,560 kg/	187,700 kg/	234,010 kg
	362,200 lbs	413,500 lbs	413,800 lbs	515,900 lbs
Centaur				
Length	9.1 m/ 30 ft	10.1 m/33 ft	10.1 m/33 ft	10.1 m/33 ft
Propellant	LH2 & LO2 (Liquid Hydrogen & Liquid Oxygen for all Atlas configurations)			
Propellant Weight	13,790 kg/	16,780 kg/	16,780 kg/	16,780 kg/
	30,400 lbs	37,000 lbs	37,000 lbs	37,000 lbs
Total Thrust (Vacuum)	146.8 KN/	148.1 KN/	180.2 KN/	180.2 KN/
	33,000 lbs	33,00 lbs	40,500 lbs	40,500 lbs
Specific Impulse Isp (Vacuum)	444.4 sec	442.3 sec	448.9 sec	448.9 sec
Atlas				
Length	22.2 m/73 ft	24.9 m/82 ft	24.9 m/82 ft	24.9 m/82 ft
Propellant	LO2 & RP-1 (Liquid Oxygen & Kerosene type fule for all Atlas configurations)			
Propellant Weight	137,530 kg/	156,260 kg/	156,260 kg/	156,260 kg/
	303,200 lbs	344,500 lbs	344,500 lbs	344,500 lbs
Booster Engines Total	1,679 KN/	1,884 KN/	1,884 KN/	1,884 KN/
Thrust (Sea Level)	377,500 lbs	423,500 lbs	423,500 lbs	423,500 lbs
Booster Engine Specific				
Impulse Isp (Sea Level)	259.1 sec	263.1 sec	263.1 sec	263.1 sec
Sustainer Engine Thrust				
(Sea Level)	269 KN/60,500 lbs for all Atlas configurations			
Sustainer Engine Specific				
Impulse Isp (Sea Level)	220.4 sec for all Atlas configurations			
Vernier Engine Total				
Thrust (Sea Level)	5,950 N/1,338 lbs	N/A	N/A	N/A
Vernier Engine Specific				
Impulse Isp (Sea Level)	186.7 sec	N/A	N/A	N/A
SRMs – 4 Used				
Propellant	N/A	N/A	N/A	HTPB
Propellant Weight per Motor	N/A	N/A	N/A	10,230 kg/22,560 lbs
Average Thrust per Motor	N/A	N/A	N/A	433 KN/97,520 lbs
Specific Impulse (Sea Level)	N/A	N/A	N/A	234 sec

Available: Now

Contact: Robert E. Dupuis, Director Business
Development & Business Management
General Dynamics
Commercial Launch Services
P.O. Box 85911
San Diego, CA 92186-5911
(619) 496-4010

Conestoga Launch Vehicle

The Conestoga Launch Vehicle is a solid-motor, small payload expendable launcher based on the Castor IV-B motor (see page 215) in various parallel configurations. The Conestoga series employs a core motor with from two to six strap-ons, all Castor IV-Bs, and a Star 37 or 48 solid orbital insertion motor. The Conestoga series is designed for Low Earth Orbit payloads from 150 to 4,000 pounds, and geosynchronous payloads from 75 to 800 pounds, depending on mission requirements. Payload shrouds from 65 to 90 inches in diameter are available and payload reentry capsules up to 80 inches in diameter can be accommodated. The Conestoga requires minimal launch pad buildup and support. Utilizing modular telecommunication, command and control, it can be launched from any site world-wide offering approved range support. The period from go-ahead to launch can be as short as 14 months.

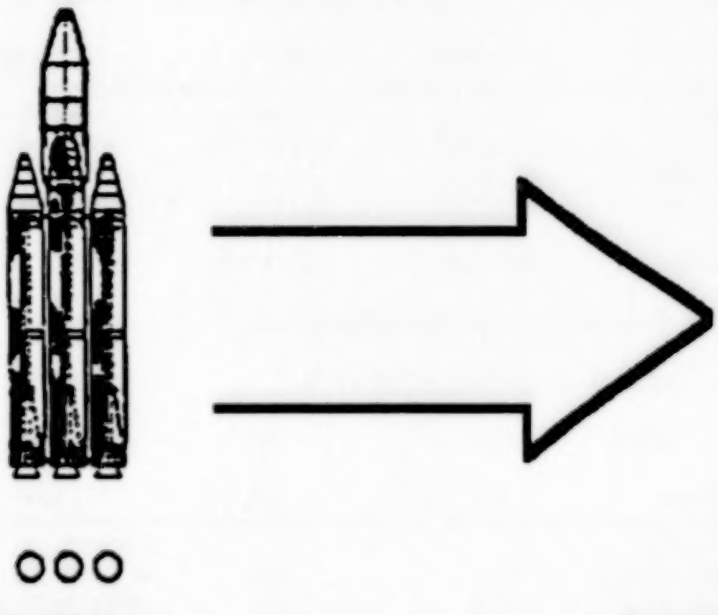
Operating Characteristics

System height:	49.5 ft maximum
Weight:	84,000 to 188,000 lbs
Guidance:	Inertial with thrust vector control

Cold gas altitude control system on cone stage
Spin stabilized upper stage (active guidance available)
Payload envelope: 190 ft^3 to 260 ft^3

Available: Now

Contact: Richard W. Scott, Jr.
Space Services Incorporated of America
7015 Gulf Freeway, Suite 140
Houston, TX 77087
(713) 649-1716, Fax (713) 649-3445



Conestoga 210
400 lbs (181 kg) - 400 nm (742 km) Polar

Conestoga 421
1500 lbs (680 kg) - 400 nm (742 km) Polar

Delta II

The Delta II launch vehicle series can be configured as a two- or three-stage vehicle and equipped with either Castor IVA solid booster motors or Graphite Epoxy thrust augmenters. Launch can be from either Cape Canaveral (ESMC), FL or Vandenberg AFB (WSMC), CA. Orbit inclinations at Cape Canaveral are from 28.5° to 51° degrees and at Vandenberg are from 63° to 145°. Payload fairings for the various launch vehicles are shown in the accompanying chart.

The Delta II series is capable of launching payloads into Geosynchronous Transfer Orbit (GTO), Low Earth Orbit (LEO), and the Global Positioning System Orbit (GPS) from Florida; and Sun Synchronous, Low Earth Orbit and a Highly Elliptical Orbit (HEO) from California.

Operating Characteristics

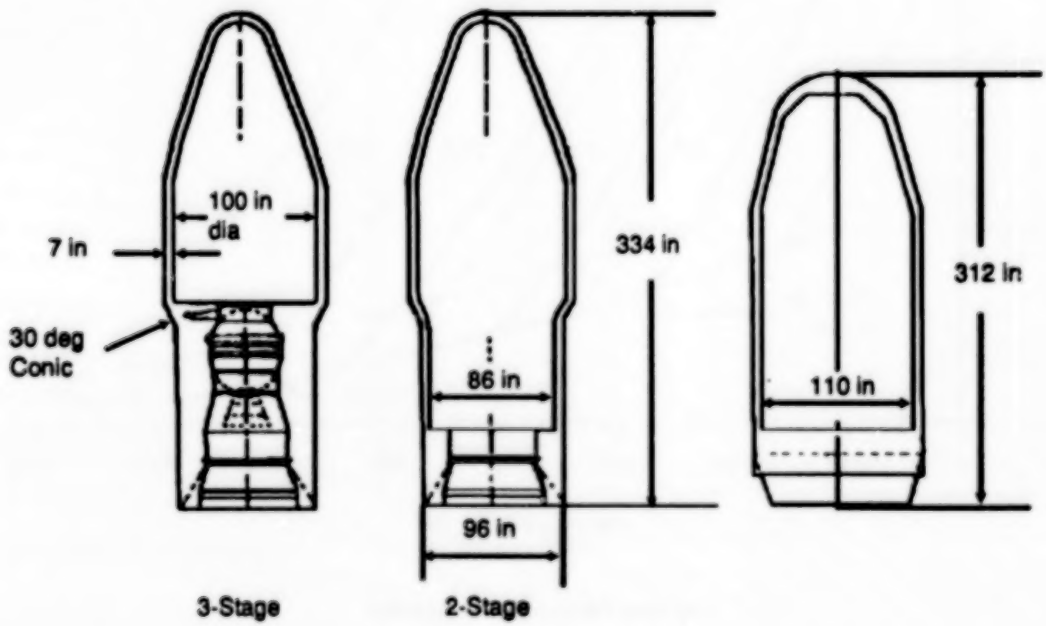
Vehicles/Orbit[1]	Spacecraft	Weight (lbs)
Three-stage Vehicles	6925	7,925
GTO (100 x 19,323 nmi, i=28.7 deg) ESMC	3190	4,010
GPS (Hc=10,898 nmi, i=55 deg)		
(Launch AZ=50 deg)	1875*	2,500*
ESMC (Launch Az=112 deg)	1850*	2,350*
HEO (200 x 21,649 nmi,i=63.4 deg) WSMC	2120	2,810
Two-stage Vehicles	6920	7,920
Sun Synchronous		
(Hc=450 nmi, i=98.7 deg) WSMC	5660	7,000
LEO (Hc=100 nmi, i=28.7 deg) ESMC	8780	11,110
LEO (Hc=100nmi, i=90 deg) WSMC	6670	8,420

[1] 9-foot fairing

* Includes empty weight of the Star 37XFP AKM after circularizing burn

Available: Now

Contact: John Fredricks
McDonnell Douglas Space Systems
1735 Jefferson David Highway, Suite 1200
Arlington, VA 22202
(703) 553-3883



Pegasus Launch Vehicle

Orbital Sciences offers complete integrated space launch services using the advanced Pegasus launch vehicle, including the provision and operation of the vehicle as well as payload integration and mission support services.

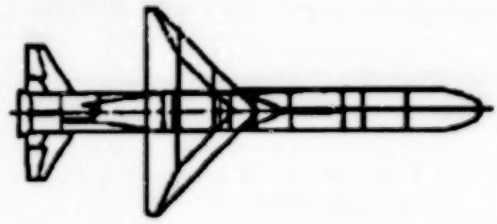
The Pegasus air-launched vehicle is a three-stage, winged, graphite composite launch vehicle that is approximately 50 feet long and 4.5 feet in diameter and weighs 42,000 pounds at launch. The vehicle uses an airborne launch from a jet aircraft to place small satellite payloads weighing up to 1,000 pounds into Low Earth Orbit. Because of its air-launched and aerodynamic lift-assisted feature, Pegasus achieves efficiency gains that enable it to lift approximately twice the payload that can be carried by comparable ground-launched vehicles. The air-launched feature also provides greater flexibility than traditional ground-launched vehicles by reducing launch site costs and geographic constraints, reducing vulnerability to weather conditions and offering a greater range of orbit inclinations.

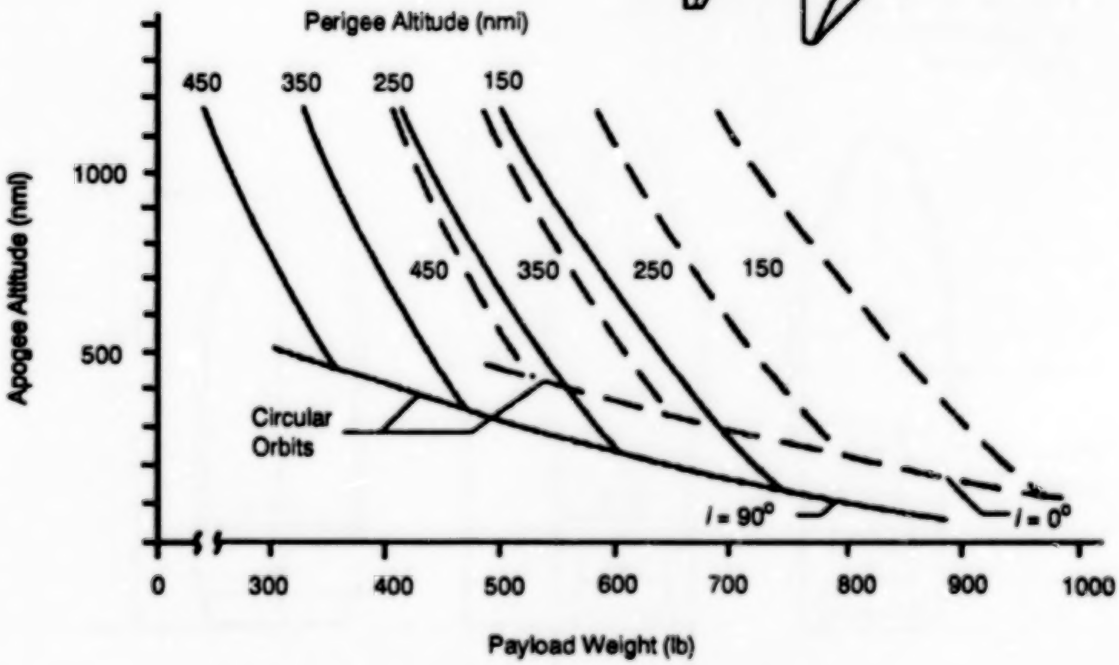
A Pegasus launch utilizes a wide-body commercial carrier aircraft or a NASA B-52 aircraft. The Pegasus launch vehicle is carried along the centerline of the commercial carrier aircraft or under the right wing of the NASA B-52. Following the drop, the first-stage motor ignites and Pegasus uses its wing to fly a shallow ascent trajectory to Mach 8.7 and 230,000 feet, where first-stage burnout and separation occur. The second- and third-stage rocket motors then function like more traditional launch vehicle upper stages to propel the vehicle's payload into orbit. The lift generated by the wing, combined with a launch initiated above 40,000 feet provides significant satellite payload-to-orbit weight benefits. Pegasus has the capability of placing 600-lb spacecraft into 250-nmi polar orbits and 900-lb payloads into 250-nmi equatorial orbits.

Pegasus has a large payload shroud with internal dimensions of 72 inches long by 46 inches wide. This large volume, combined with the 600 to 900-lb payload capability, can accommodate innovative satellite designs, including imaging spacecraft requiring large diameter optics.

Available: Now

Contact: Bruce A. Biehler
Orbital Sciences Corporation
Space Systems Division
12500 Fair Lakes Circle
Fairfax, VA 22033
(703) 631-3600





Pegasus Payload Performance

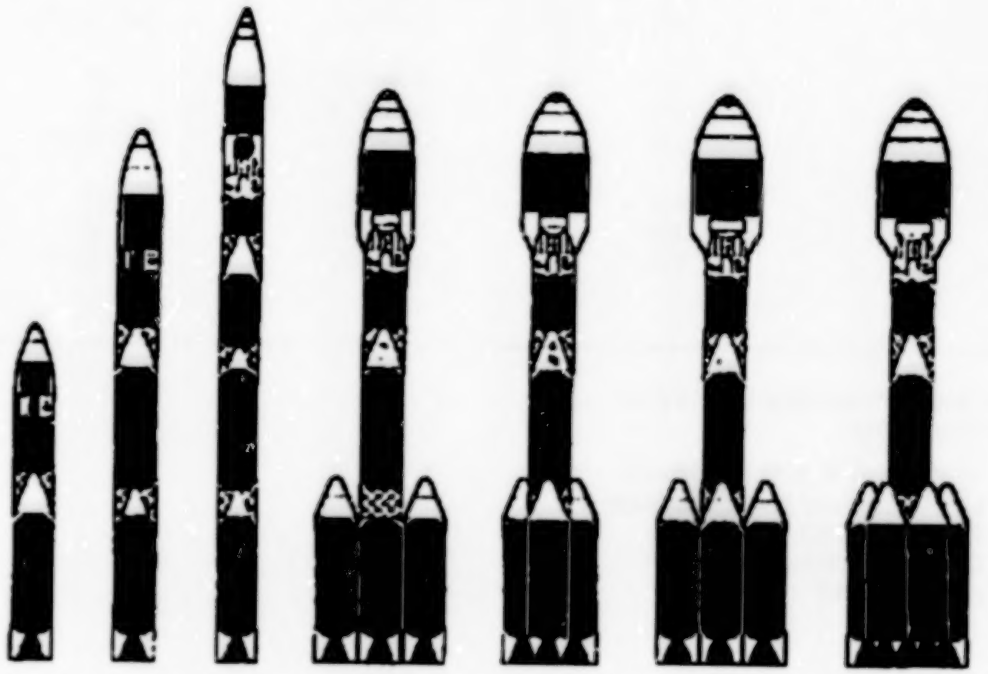
S-Series Medium Lift Launch Vehicles

The EPAC S-Series ELV has a three-stage solid rocket motor (SRM) core configuration. Performance capability in terms of payload weight is a function of both mission trajectory requirements and vehicle configuration (e.g., the basic core vehicle capacity can place payloads of up to 20,000 pounds into Low Earth Orbit, or payloads up to 7,800 pounds into Geosynchronous Transfer Orbit).

The S-Series is a five configuration family providing an efficient means of propelling a wide range of space payloads into planned trajectories. The SRMs are chosen to meet the propulsion requirements of the payload orbital position specifications. Two, three or four SRM stages are configured with or without SRM thrust augmentation motors. A storable liquid positioning module can be added to provide the remaining propulsion and accuracy for placing various payloads into Geostationary Transfer Orbit. These vehicles have 92-inch core diameter and range in height from 76 to 115 feet.

Available: Now

Contact: E'Prime Aerospace Corporation
P.O. Box 792
Titusville, FL 32781
(407) 269-0900



EPAC S-Series Launch Vehicles

Scout

The Scout is a four-stage solid rocket expendable launch vehicle manufactured and launched by LTV Missiles and Electronics Group. It is capable of providing orbital, reentry or probe missions. Scout has experienced a mission success ratio of 98.3 percent over the past 22 years.

Since the initial Scout launch, Scout's payload mass carrying capability has increased three to four times while increasing overall reliability. To further increase performance capability, LTV and BPD of Italy, have begun development of a more powerful version of the Scout; the Scout II. Scout II utilizes the Scout as the core vehicle and has two BPD-tailored Ariane-4 solid rocket motor strap-ons. The fourth-stage ALTAIR IIIA motor is replaced with the BPD Mage 2. Additionally, a third Scout configuration is under development; the Enhanced Scout. The Enhanced Scout is identical to the Scout II, except the Scout fourth-stage ALTAIR IIIA rocket motor is retained.

Scout has launch facilities at the Western Test Range, Vandenberg Air Force Base, CA; Wallops Flight Center, Wallops Island, VA; and San Marco Equatorial Mobile Range, located in Ngwana Bay of the Indian Ocean (off the east coast of Kenya, Africa).

Operational Capability

	Payload Wt. (kg)	Orbit (km)	Inclination Angle (Deg)
Scout	225	500x500	0-5
	170	500x500	90
	165	500x500	Sun-Synch
Enhanced Scout	400	500x500	0-5
	304	500x500	90
	295	500x500	Sun-Synch
Scout II	434	500x500	0-5
	334	500x500	90
	324	500x500	Sun-Synch

Available: Scout, immediately; Scout II and Enhanced Scout, 1993

Contact: W. R. Ray or H. E. Collins, MM-52
LTV Missiles and Electronics Group
P.O. Box 650003
Dallas, TX 75265-0003
(214) 266-7612

Taurus Launch Vehicle

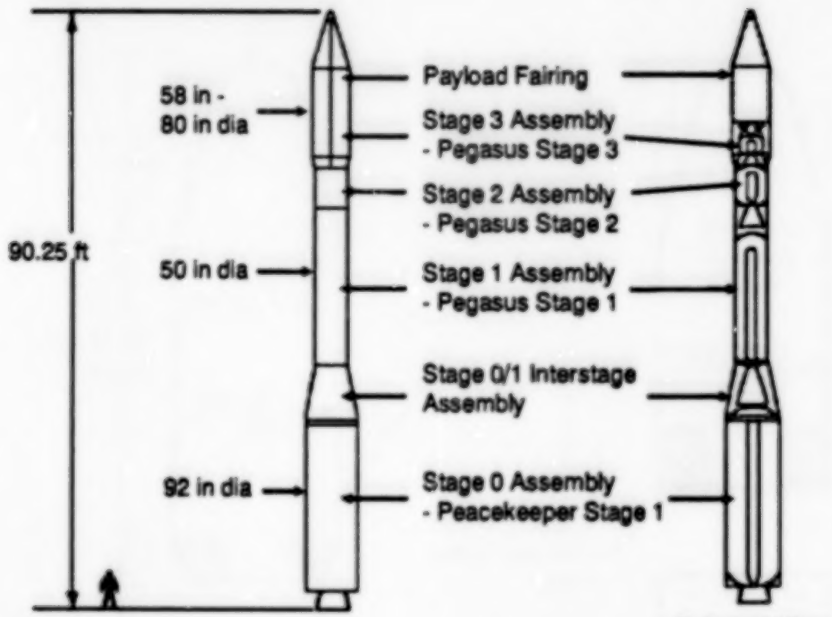
Orbital Sciences offers complete integrated space launch services using the advanced Taurus Launch Vehicle, including the provision and operation of the vehicle as well as payload integration and mission support services.

Currently under contract and development, Taurus is a four-stage, ground-launched vehicle derived from the flight-proven Pegasus vehicle (see page 208). The Taurus design provides for use of the Pegasus launch vehicle's avionics, control module and rocket motors, supplemented by a U.S. Air Force Peacekeeper or equivalent missile stage zero motor. The stage 0 motor design features an omni-axis movable carbon phenolic nozzle, with thrust vector control for pitch and yaw provided by a flex seal nozzle with turbo-hydraulic actuation. Taurus is approximately 90 feet long and 8 feet in diameter at its widest point and weighs about 175,000 pounds at launch. It is designed to be readily transported with a self-contained launch pad, including assembly and pre-flight testing equipment, so that launch from a variety of developed or remote locations can be achieved.

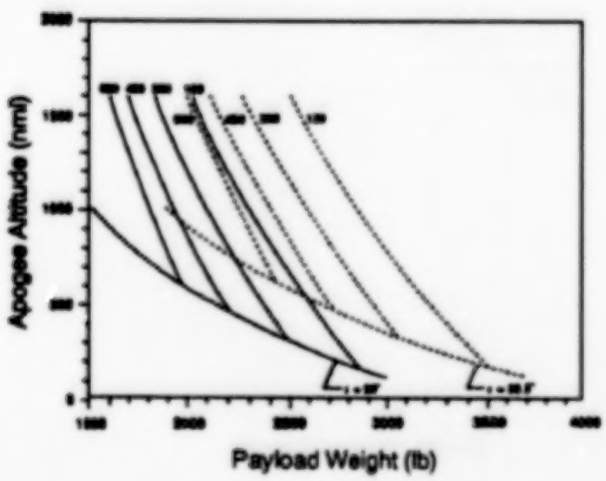
It is expected that Taurus will launch payloads weighing up to 3,500 pounds into Low Earth Orbit and up to 830 pounds into Geosynchronous Transfer Orbit. Injection accuracies to a 400 nm circular polar orbit are expected to be better than +/-20 nmi in altitude and +/-0.2 degrees in inclination.

Available: 1992

Contact: Bruce A. Biehler
Orbital Sciences Corporation
Space Systems Division
12500 Fair Lakes Circle
Fairfax, VA 22033
(703) 631-3600



Cutaway View



Taurus Payload Performance
(Enhanced Vehicle)

Titan III

The baseline mission for the Titan III commercial launch vehicle is to insert payloads into Low Earth Orbit. Missions are flown into a park orbit of 80 x140 nmi at an inclination of 28.6°. The Titan III delivers 31,600 lbs into this LEO in the dual payload configuration or 32,500 lbs in the single payload configuration when launched from Cape Canaveral in Florida.

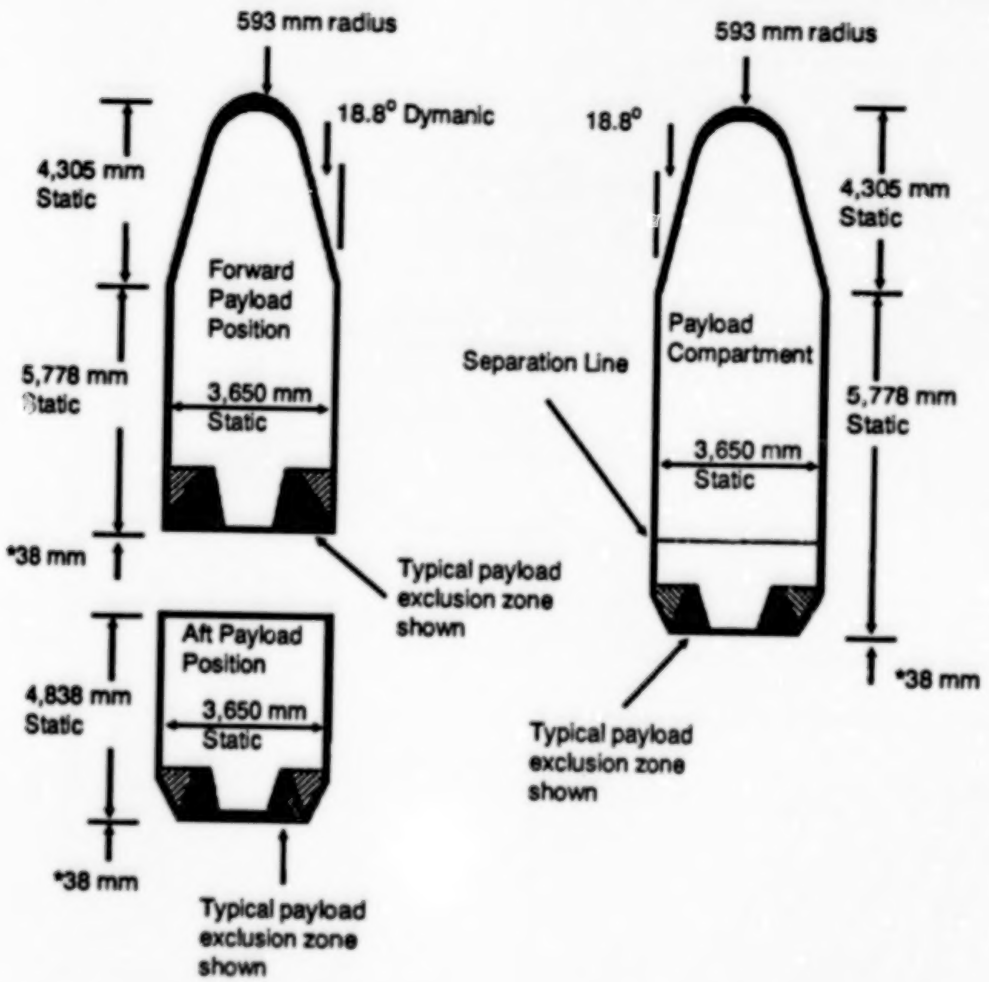
The Titan III system is capable of providing a full complement of payload accommodation services, including: payload integration analysis and verification, launch site payload processing facilities, mission safety verification, launch pad test and checkout support, airborne avionics integration and post flight data analysis. A standard set of services is included with each contract, with additional services provided depending on specific payload mission requirements. The initial launch of the Titan III commercial launch vehicle was December 1989.

Operating characteristics

System height:	Up to 155.0 ft
Payload carrier length:	Up to 52 ft
Payload carrier diameter:	13.1 ft

Available: Now

Contact: Timothy C. Abels
Manager, Government Systems
Martin Marietta Commercial Titan, Inc.
P.O. Box 179, MS DC1450
Denver, CO 80201
(303) 971-1586, Fax (303) 971-2390



*Dynamic exclusion zone

Dual Payload Carrier **Single Payload Carrier**

Reentry Vehicles

Reentry vehicles are designed to be launched into space with a payload module, remain (all or in part) with the payload during space exposure and then, usually upon command from ground-based operations, return to the atmosphere for recovery at a specified location. Reentry vehicles initially were designed with the first manned space flights in the 1960s, when an astronaut was launched into orbit by an expendable launch vehicle and returned safely to Earth. American astronauts traditionally floated through the atmosphere with parachutes attached to their spacecraft, landing in the water for recovery by the Navy.

As research programs in space mature and require more sophisticated data results and testing, the need for recoverable payloads increases. As a result, considerable research and development is underway, both by NASA and the private sector, to make these essential vehicles available.

COMmercial Experiment Transporter Program (COMET)

In 1990, NASA's Centers for the Commercial Development of Space jointly established a new initiative, the COMmercial Experiment Transporter Program (COMET), for launching and recovering commercial spaceborne experiments. The objective of the program is to develop both the hardware and infrastructure essential to facilitate innovative U.S. efforts to commercially develop space. With NASA's support, the CCDS's will be responsible for system design, fabrication, testing and operations.

The Center for Advanced Space Propulsion (CASP) at the University of Tennessee is responsible for program management and systems engineering. The six major elements of the COMET program include: launch vehicle and services, payload integration, service module, orbital operations, recovery system and services and systems engineering. Contractors are providing key hardware and services for each segment of COMET development and operations.

An expendable launch vehicle (ELV) will launch the COMET freeflyer, which will contain both a service module and a recovery system. The components will separate prior to reentering the atmosphere, allowing many of the experiments to return to Earth in the recovery system, while others, not requiring retrieval, can continue their mission aboard the service module. Launching on ELVs will give commercial developers the flexibility of orbital parameters that is not available with the Shuttle.

Present plans call for the first launch in mid-1992. The freeflyer, weighing up to 1800 pounds, will be placed into equatorial orbit with an inclination of about 40 degrees. Recoverable payloads nominally will have a 30-day mission, while non-recoverable payloads can remain on orbit in the service module for a year or longer. Specific launch and recovery sites will be selected through industry's proposals for the most optimal way to meet mission requirements.

In addition to CASP, other CCDS participants include:

- Payload Integration; Center for Macromolecular Crystallography, University of Alabama/Birmingham
- Recovery System; BioServe Space Technologies, University of Colorado/Boulder
- Service Module; Center for Space Power, Texas A&M University/College Station
- Expendable Launch Vehicle; Consortium for Materials Development in Space, University of Alabama at Huntsville
- Orbital Operations; Space Vacuum Epitaxy Center, University of Houston

The experimental payloads will be selected from the CCDS's and their industrial partners. The launch vehicle, recovery and reentry systems, and associated on-orbit and ground-support services are being purchased by competitive bid from private industry.

Contact: Joseph F. Pawlick, Jr.
COMET Program Manager
University of Tennessee Space Institute
UT-Calspan Center for Aerospace Research
P.O. Box 1385
Tullahoma TN 37388
(615) 454-9294

Orbital Payload Recovery Systems

The Reentry/Recovery Vehicle Division of COR Aerospace Corporation is dedicated to the design and development of vehicle systems for the autonomous recovery, from orbit, of a broad spectrum of commercial and scientific payloads. Orbital Payload Recovery System designs employ two basic vehicle types. Both are readily scalable to accommodate diverse payload requirements and a broad spectrum of launch system capabilities. The systems illustrated are representative of a number of vehicles of specific, prospective applications.

The "CHEOPS" concept is fully autonomous in operation. Following deployment and an orbital dwell period as dictated by payload requirements, it reenters on command and is recovered fully intact. This ensures against debris impact in the recovery area and facilitates the economy of refurbishment and reutilization of the total vehicle.

The spherical "Deliverer" vehicles are generally smaller, highly simplistic systems, which deploy in orbit from a companion satellite. The satellite provides gravity-gradient stabilization, power for payload functions and up-and-down link communication, prior to separation for vehicle reentry. This system discards its deorbit module (spent retrorocket and spin system) after initiation of reentry but allows for reuse of the remaining reentry vehicle.

CHEOPS "64" Operational Characteristics

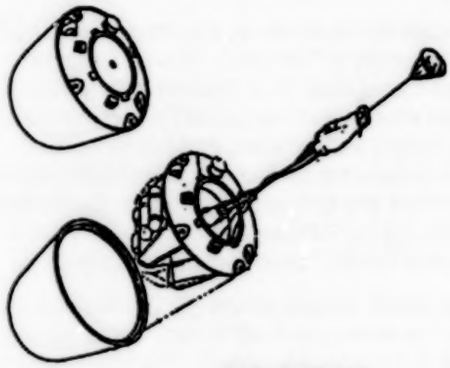
Shape:	Blunt Sphere/Cone
Size:	64 inch Base diameter
Total weight:	2600 lbs/2175 lbs
Total R/V Sys. Wt:	2600 lbs/2175 lbs
Reentry weight:	2350 lbs/1968 lbs
Payload volume:	19.0 cubic ft
Payload weight:	1575 lbs/1159 lbs
P/L mass fract:	0.61/0.53
Ballistic coeff. (B):	165 psf/138 psf
Autonomy:	Full
% Reuse:	85% estimated
Debris:	None
Term. descent:	Controlled Chute
Pref. recov. site:	Land

Deliverer "24" Operational Characteristics

Shape:	Spherical
Size:	24 inch diameter
Total weight:	685 lbs
Total R/V Sys. Wt:	446 lbs
Reentry weight:	380 lbs
Payload volume:	2.0 cubic ft
Payload weight:	250 lbs
P/L mass fact:	0.36
Ballistic coeff. (B):	121 psf
Autonomy:	Requires companion satellite
% Reuse:	40% estimated
Debris:	Deorbit Module Remains
Term. descent:	Controlled Chute
Pref. recov. site:	Land

Available: Under development

Contact: Roland T. Mayer
Reentry/Recovery Vehicle Division
COR Aerospace Corporation
1495 Anthony Wayne Dr.
Wayne, PA 19087
(215) 964-9665



™CHEOPS-64

™Deliverer "24"

Orbital Transfer Vehicles

Orbital transfer vehicles carry satellite payloads from locations between Low Earth Orbit (200 miles) and Geostationary Orbit (22,300 miles) or to planetary trajectories. The vehicle and its attached payload typically are carried by the Shuttle or expendable launch vehicle into a low-altitude "parking" orbit, usually 150 to 200 miles above the Earth. The transfer vehicle then lifts its payload into an operational orbit, or a trajectory. Once properly situated, the vehicle separates from the payload.

The applications for orbital transfer vehicles are many, but the development of such vehicles has been limited. NASA has developed plans for an Orbital Maneuvering Vehicle (OMV) and studies have suggested that reusable rocket stages or discrete vehicles, that could be refueled in orbit, could provide the energy increment to raise and lower satellites or platforms between a servicing altitude and an operational altitude. In the future, other scientific or commercial missions may require a change of orbital plane to observe targets of opportunity or to optimize the scientific or application return. Transfer vehicles will be needed for manned and unmanned operation as missions dictate. With the development of Space Station Freedom, the need for on-orbit, or inter-orbital transportation will become even more essential. Orbital transfer vehicles will be an indispensable tool for operations at stations, platforms, satellites and other facilities in Earth, lunar and Martian orbits.

Transfer Orbit Stage (TOS)

The TOS vehicle is a single-stage solid-propellant rocket that measures approximately 7.5 feet in diameter and 10.5 feet in length and weighs up to 24,000 pounds. The TOS was engineered to be compatible with both the Shuttle and Titan ELV. TOS/STS performance is referenced for a 160 nm park orbit while TOS-on-Titan performance is referenced for a 90 nm park orbit perigee. TOS payloads typically consist of communications satellites, scientific probes or other commercial and defense spacecraft weighing between 3,000 and 7,000 pounds.

TOS propulsion consists of a main propulsion system and an attitude control system (ACS). Both systems have extensive hardware heritage with a large number of successful ground and flight tests on NASA and military space programs. Both combine selective redundancy with conservative design margins to assure high levels of safety and reliability. The ORBUS 21 solid rocket motor (see page 219) provides TOS main propulsion. The ORBUS 21's gimballed nozzle provides pitch and yaw control during motor firing. This motor's 50% propellant off-load capability accommodates a wide range of mission payload and energy requirements. A blow-down monopropellant hydrazine system produced by United Technology Corporation's Hamilton Standard Division provides ACS and velocity trim propulsion. Roll control during solid rocket motor firing and three-axis attitude control during coast is provided by 12 ACS thrusters.

TOS avionics hardware and software perform all functions involved in guidance and control, data management, event sequencing, telemetry and command and electrical power. Orbital Sciences Corporation has qualified an operationally simple but exceptionally powerful guidance, navigation and control capability using Honeywell's advanced laser inertial navigation system (LINS), enabling TOS to provide high injection accuracy and reliability at low cost. Under development by OSC and Honeywell since 1984, the LINS has pioneered the qualification of ring laser gyroscope avionics for space applications.

The TOS structural design provides uniformly-distributed load paths between the flight vehicle and ASE, allowing weight reductions not possible with discrete attachments. The tilt method of deployment and the Lockheed Super-Zip separation system both have extensive flight history.

Available: Now

Contact: Martin Deckett
Orbital Sciences Corporation
Space Systems Division
12500 Fair Lakes Circle
Fairfax, VA 22033
(703) 631-3600

Chapter 21: Ancillary Products and Services

A number of products and services are available to support the transportation industry, vehicles and systems. These include propellants, avionics, motors, parts and others. When on-orbit facilities become operational later in the decade, requirements for space-based transportation services will evolve, potentially stimulating a new sector of the industry. This chapter includes some of the products and services that are available and are being developed.

Brushless Space-Rated Motor

Thirteen of these motor/brake units were designed, built and qualified in four months. They were designed for deep space and use low outgassing components. The application requires six motor/brakes to deploy three masts on a satellite.

Operational Characteristics

Peak Torque:	25 in-oz @ 3.0 Amp
Maximum speed:	5,000 rpm @ 34 Vdc
Size:	2.50 in diameter x 6.80 in L
Weight:	3.0 lbs

Available: Now

Contact: Versatron Corporation
103 Plaza Street
Healdsburg, CA 95448
(707) 433-8244, Fax (707) 433-7110

Castor Launch Vehicle Propulsion

Castor rocket motors have been used as primary or augmenting propulsion for orbital and sub-orbital launch vehicles since the 1950s. As of 1990, more than 1,750 Castor motors have flown with a success record of 99.94 percent.

All Castor motors use a rugged, low-cost roll-and-welded steel motor case in diameters of 31 and 40 inches. Solid propellant weight ranges from 7,300 to over 22,000 pounds. Each motor has forward and aft attachment skirts, capable of supporting the full thrust load. Motors are available with straight, canted, sea level and altitude nozzles. The Castor IVB has a +/-6 degree omniaxial thrust vector control system with a hydraulic blow-down actuation system.

Optional accessories include a destruct system; shipping dollies; arm and fire device; clustering or strap-on hardware; ordnance, electrical or laser ignition; full length wiring tunnels; external cork or spray-on insulation; and nose cones.

Available: Delivery is nominally 12 to 16 months; Castor IVH and Castor V are under development.

Contact: Donald G. Wilson
New Business
Development Manager
Thiokol Corporation
P.O. Box 400006
Huntsville, AL 35815-1506
(205) 882-8000

Castor I

Castor II

Castor IVA

Castor IVB

Cryogenic Propellants

Air Products and Chemicals produces cryogenic propellants, pressurants and purging agents for launches. Capabilities include the supply of propellant-grade liquid hydrogen, oxygen and methane, as well as nitrogen, argon and helium.

Contact: Air Products and Chemicals, Inc.
Government Systems
7201 Hamilton Boulevard
Allentown, PA 18195-1501
(215) 481-4911

Launch Vehicle Avionics

Interferometrics has built and flight-tested a complete set of low-cost avionics and electronic subsystems for commercial launch vehicles, using off-the-shelf components and custom microelectronics. These avionics, developed for the American Rocket Company's Industrial Launch Vehicle, are available as individual subsystems or as a complete integrated package. Engineering support includes mission planning and analysis, guidance and control system design and evaluation, system integration, test and operational support.

Hardware Includes:

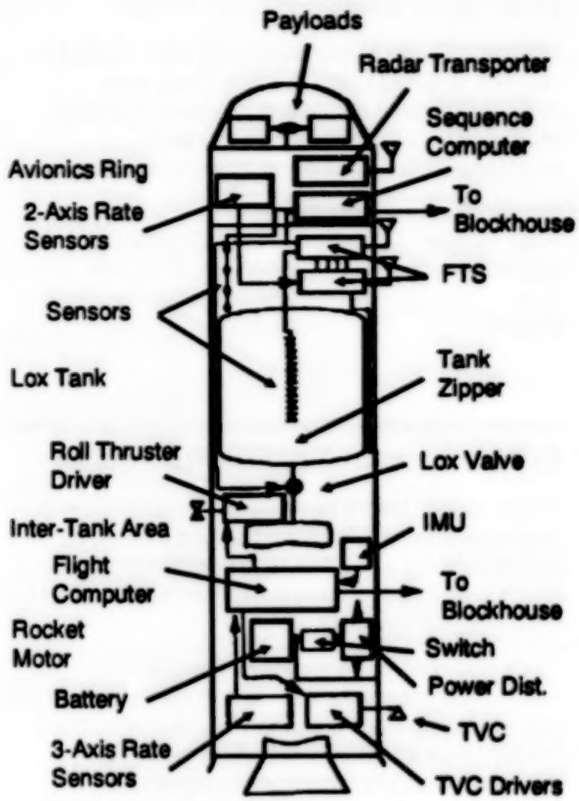
- Flight Computer (FC)
- Flight Termination System (FTS)
- Batteries & Power Conditioning Units
- Telemetry & Tracking System (TTS)
- Flight Data Acquisition & Multiplexer
- Payload Activation System
- Launch Sequence Computer System
- Thrust Vector Control System (TVC)
- Inertial Measurement Unit (IMU)
- Vehicle Instrumentation Sensors
- Altitude Control System (ACS)

Software Includes:

- Guidance & Control Programs
- Launch Control Software
- Critical Flight Code
- Six-DOF Simulator
- Mission Planning Software
- Structural Mode Analysis

Available: Now

Contact: Dino A. Lorenzini
Vice President, Operations,
Interferometrics, Inc.
8150 Leesburg Pike Suite 1400
Vienna, VA 22182-2799
(703) 790-8500, Fax (703) 848-2492



On-Orbit Transportation Services

GLOBAL OUTPOST, Inc. plans to offer transportation-related services beginning in 1993-94. The company is developing a fluid transfer location on the initial OUTPOST Subsystem package (see pages 170-171) which will have limited storage tanks. Couplings from third-party developers will provide on-orbit storage and transfer of fluids in both directions. A passive platform interface location will provide structural attachment, electrical, thermal, communications, command and control, storage and other services to freeflyers and expendable launch vehicles having an ability to rendezvous and dock, and requiring some or all of these services.

The company anticipates a limited capability to unload vehicles using robotic hardware and /or dispose of vehicle hardware.

Location: OUTPOST Platform (Low Earth Orbit)

Available: 1993-94

Contact: William A. Good
GLOBAL OUTPOST, Inc.
P.O. Box 4321
Highlands Ranch, CO 80126
(303) 791-6277

ORBUS Space Motors

The ORBUS series of space motors was developed to satisfy specific space requirements and have supported the following applications:

ORBUS 6
Shuttle payloads, Titan 34D payloads

ORBUS 6E
Shuttle payloads

ORBUS 6S
Titan 34D Inertial Upper Stage apogee motor, Shuttle Inertial Upper Stage apogee motor

ORBUS 7S
Perigee motor for Hughes HS-393 series communication satellites

ORBUS 21
Titan 34D Inertial Upper Stage, Shuttle Upper Stage

ORBUS 21S
Perigee motor for INTELSAT-VI satellites

Available: Now

Contact: Larry Ross, Marketing Manager
Chemical Systems Division
United Technologies Corporation
P.O. Box 49028
San Jose, CA 95161-9028

Proximity Switch System

The ELDEC Proximity Switch System provides door and landing gear position indication for the Shuttle. The system is comprised of two 10-channel electronics packages, remotely located proximity sensors (up to 10 per electronics package) and a target for each sensor. When a target is brought within a specified actuation envelope of a proximity sensor, the electronics package will provide a discrete output for that channel.

Typical Indication Includes:

- Nose Landing Gear Weight on Wheels
- Main Gear Downlocked (R&L)
- Main Gear Uplocked (R&L)
- Main Gear Door Uplocked (R&L)
- Nose Landing Gear Door Uplocked (R&L)
- Main Gear Weight on Wheels

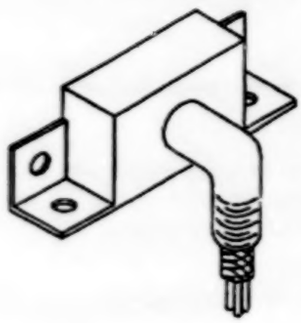
Operational Characteristics

Electronics Package	
Size:	3.72 in x 4.10 in x 8.00 in
Input power:	115 Vac, 400Hz
Proximity Sensor	
Size (typ):	0.50 in x 0.90 in x 1.20 in

Locations: Shuttle cargo bay and landing gear

Available: Now

Contact: ELDEC Corporation
Monitor and Control Division
16700 13th Avenue West
Lynnwood, WA 98037-8503
(206) 743-1313



RL10-A-3-3A Space Engine

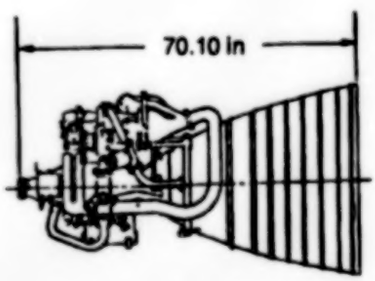
The RL10-A-3-3A is a liquid hydrogen-fueled engine with a highly-efficient expander cycle, ideally suited for applications requiring restart capability, with large variations in coast periods between firings. The engine can be modified for lower (down to 7,500 lbs) or higher (up to 22,000 lbs) thrust ratings to adapt to future needs. The mixture ratio is variable from 4:1 to 7:1. The nozzle area ratio also can be tailored to specific vehicles and two-position nozzle extensions are under development.

Operational Characteristics

Thrust vacuum:	16,500 lbsWeight: 305 lb
Mixture ratio (lb O2/lb H2):	5:1
Specific impulse vacuum:	444.4 sec
Chamber pressure, psia:	475 (327 bar)
Area ratio:	61:1
Qual life, firings/hr:	20/1.25

Available: Now

Contact: James R. Brown
RL10 Engine Program Manager
United Technologies/Pratt & Whitney
P.O. Box 109600
West Palm Beach, FL 33400-9600
(407) 796-3371



STAR Space Motors

Thiokol's STAR family of space motors provides reliable propulsion for spacecraft and launch vehicle upper stages. Designed to provide maximum payload capability by using high-specific-impulse propellants and advanced materials, more than 60 different STAR motors have been developed and qualified (see listing). The STAR number for each motor indicates its approximate principal diameter in inches, while the letter designations are used to denote configurations tailored to a particular set of requirements.

Performance is tailored within our family of existing qualified motors either by decreasing the propellant weight loaded into the motor, or by increasing motor case length to increase motor volume, thereby permitting increases in propellant loading. These approaches permit a wide range of performance to be achieved for specific missions without changing the basic motor configuration.

Another characteristic of the STAR motor family is the delivery of total impulse in vacuum, predictable within 0.5% and reproducible within 0.6R over a 30° to 100°F temperature range.

Motor Characteristics

Name	Star No.	Motor Weight (kg)	Tested	Flown as of April 23, 1990
Perigee Kick Motor	75	7,938	1	–
AUSSAT	63F	4,644	4	–
PAM-DII	63D	3,498	5	3
Perigee Kick Motor	48A	2,420	1	–
Shuttle & Delta Payload Assist Module	48B	2,135	3	17
Shuttle & Delta Payload Assist Module	48	2,107	18	31
Antares III, Scout Third Stage	31	1,393	6	11
Improved Performance Space Motor	37Y	1151	2	–
Improved Performance Space Motor	37X	1151	1	–
FLTSATCOM (EHF) Apogee	37FM	1145	4	2
Improved Extended Delta	37G	1141	4	–
Delta 2914/3914, Atlas-Centaur	37E	1122	13	78
Titan-Centaur GPS, Block 5D and Japanese N-2 Upper Stage Delta 2914 Third Stage	37C	1047	1	8
GPS, KuBAND Apogee	37XFP	656	3	10
Improved Intelsat V, GPS Phase III Apogee	37XF	942	9	10
FLTSATCOM, Intelsat V Apogee	37F	933	8	11
Star 37B Burner II, 37D Delta, 37N Japanese N-1 Upper Stage Motors, 37S Block 5-D, and TIROS-N Orbit Insertion	37B,D,N,S	718	18	69
Surveyor Main Retro	37	621	50	7
Skynet 4 Apogee	30E	660	3	2
GSTAR, ASC, and DBS Apogee	30C	621	4	5
Space, GSTAR, MORELOS, TELSTAR and AUSSAT Apogee	30BP	543	5	16
SBS, SATCOM, WESTAR, ANIK, PALAPA, Galaxy, TELESTAR, Spacenet and BRASILSAT Apogee	30B	537	14	30
Apogee Motor	30,30A	492	4	–
CTS, GMS I/II, BSE and BS II, GPS I/II, NTS, P78-1, GOES D, E, and F, CS-2 SANDIA LABS, NATO III Apogee	27	363	16	31
Advanced Altair	20A	314	2	–
ASAT	20B	306	6	5
Altair III, Scout Fourth Stage	20	301	9	28
Viking, Dot and STRYPI Upper-stage	26C	263	4	14
Burner IIA Apogee	28B	261	1	8

STAR Space Motors (continued)

Motor Characteristics (continued)

Name	Star No.	Motor Weight (kg)	Tested	Flown as of April 23, 1990
IUE Apogee	24C	239	1	1
Pioneer Venus, Timation III (STP-73-3), LAGEOS and SKYNET II Apogee	24	218	8	5
IMP H & J Apogee	17A	126	3	2
SOLRAD, STP 72-2, S-3, SKYNET I and NATO I Apogee	17A	126	7	7
Radio Astronomy Explorer (RAE), S-3 and Solrad Apogee	17	79	6	4
AMPTE Apogee	13B	47	1	2
SESP, LES, AND S-3 Apogee	13A/F	38	5	8
Interplanetary Monitoring Platform (IMP D & E) Orbit Insertion	13	36	7	2
Super SARV Retro	12A	33	6	
SARV Retro	12	28	160	350
Re-entry Control	6B	10.3	8	14
Drag Make-up	6	6.1	47	247
	6A	4.7	47	247
Orbit InsertioN	5A	4.6	5	2
Titan Retro	5C	4.5	226	674
Trailblazer			4	11

Available: Now

Contact: Thiokol Corporation
Tactical Operations, Elkton Division
P.O. Box 241
55 Thiokol Road
Elkton, MD 21921-0241
(301) 392-1111

Thermal Protection

Exterior temperature-resistant components used in the Shuttle program protect the orbiter's aircraft-like structure from surface temperatures to 2200°F. Interior thermal components provide stable temperature environments for personnel and electronic equipment during the various mission phases.

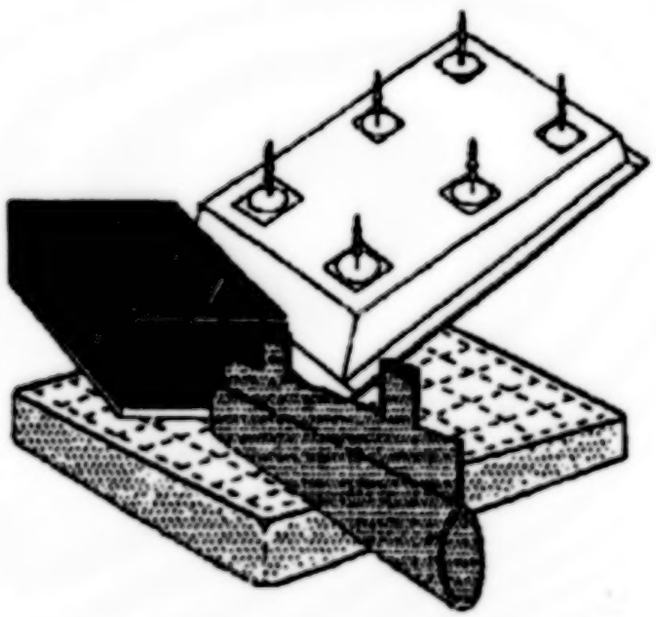
The Thermal Protection System (TPS), designed for 100 Shuttle missions, is comprised of ceramic tile; quilted flexible quartz and aramid felt insulating blankets; alumina-boria-silica fabric thermal barriers; and special coated fabrics. The over 24,000 rigid, low density fibrous silica tiles used on each Shuttle are machined to various geometries using numerically-controlled mills. The tile dimensions are held to exacting tolerances to maintain minimum weight/maximum heat protection. The tiles are covered with a thin glass ceramic, optical coating to achieve necessary on-orbit and reentry heat protection and to prevent surface erosion. The quilted blankets, coated with a silica ceramic slurry, have a service temperature of 1500° F. Aromatic nylon felt blankets, coated with silicone paint, are used in areas less than 700° F. Thermal barriers are made of various types of high temperature fabrics, battings and specialized internal details for use with dynamic structure penetrations. Other fabric materials have ceramic and silicone rubber impregnated coatings.

The Thermal Control System (TCS) uses blankets fabricated from aluminized polyamide film and teflon-coated fiberglass materials. The insulating properties are achieved by multi-layering the film with dacron net separators or filling with fibrous batting. Fabrication capabilities include numerical control programming, NC and duplicating mills, various types of instrumentation, laser part digitizing, unique machine stitching, high-temperature glazing, vapor phase waterproofing and rubber transfer coating. Installation of TPS/TCS components uses various room temperature vulcanizing (RTV) silicone rubber adhesives and mechanical attachment methods, along with time proven techniques. Statistical process controls are employed to assure consistent product conformity.

Location: Shuttle (other applications possible)

Available: Now

Contact: Richard E. Hammons, Manager
Space Systems Division
Rockwell International Corporation
12214 Lakewood Boulevard
MS/PL29, Department 188
Downey, CA 90241
(805) 272-4262



Section Seven: Resources & Services

In addition to the scientific, engineering and technical support services and equipment described in this catalogue, there are many other resources available to commercial developers from NASA, other federal and state agencies, organizations and commercial firms. Whole new segments of the "commercial space community" have developed with these emerging activities, such as space law, intellectual property, insurance, management consulting, project assessment and scheduling, investment research and counseling, payload testing and processing as well as creative support services. The entries included in this section represent but a small sampling of the spectrum.

Chapter 22: Industry

Industry offers products and services to commercial space developers, from cryogenic propellents to creative consulting, from operations management to flight simulation, from neural networks to liability insurance. As in any growing business, the very nature of the challenge draws enterprising supporters.

Air Products and Chemicals, Inc.

Air Products and Chemicals, Inc. provides ground-based services ranging from the supply of cryogens to designing, engineering, installing and operating custom-tailored systems to meet the requirements for propellant production, storage, distribution and application at both test and launch sites.

Contact: Larry Belnoski, Manager
Cryogenic Propellants and Systems
Government Systems
Air Products and Chemicals, Inc.
7201 Hamilton Boulevard
Allentown, PA 18195-1501
(215) 481-4911
(Locations also available in England and France.)

American Institute of Aeronautics and Astronautics (AIAA)

The American Institute of Aeronautics and Astronautics provides technical information services and an aerospace database. Information products include:

The Aerospace Database (file 108 on DIALOG)
The electronic version of International Aerospace Abstracts (IAA) and Scientific and Technical Aerospace Reports (STAR).

Aerospace Database OnDisc
The CDROM version of the online database. Available either: current year + 1 year backfile or current year + 4 years backfile.

International Aerospace Abstracts
Abstracting, indexing and bibliographic information on international research in the aerospace field and related fields.

Aerospace Research Bulletins
Current awareness bibliographies covering contemporary aerospace research.

Finding Guide to AIAA Meeting Papers
Published yearly.

Contact: Technical Information Service
American Institute of Aeronautics and Astronautics
555 West 57th Street
New York, NY 10019
(212) 247-6500

American Space Technology, Inc. (AmSpace)

AmSpace provides technical services including:

- Microgravity experiment design, analyses, fabrication and testing in the areas of combustion, materials and life sciences
- Space systems studies, design, analyses, traceable requirements definitions for mission, functional, interface and verification
- Attached and freeflyer spacecraft systems design support for Low Earth Orbit, Geosynchronous Orbit and planetary spacecraft
- Payload integration studies for Shuttle, Space Station, booster stages, spacecraft and Get-Away-Specials
- Detailed design and analyses for electronics, software structures, heat transfer, propulsion and materials
- Program management, costing, critical path network development/analysis and related scheduling

Contact: Arthur T. Perry
American Space Technology, Inc.
(AmSpace)
2800 28th Street, Suite 351
Santa Monica, CA 90405-2936
(213) 450-7515

Arthur D. Little, Inc.

Arthur D. Little, Inc. designs and assembles various space based experiments and space hardware including:

- Blood storage experiment flown on Shuttle
- Passive radiative cooler
- Heat transfer pump/thermal control system
- Lunar heat flow probes
- Lunar Gravimeter
- Laser ranging retro-reflector for measurement of to-moon distances

Contact: Peter Glaser, Vice President
Arthur D. Little, Inc.
20 Acorn Park
Cambridge, MA 02140
(800) 677-3000

Booz-Allen & Hamilton, Inc.

The Space Systems and Technology Division of Booz-Allen & Hamilton is a technical consulting organization specializing in space systems development and operations management. It has locations in Washington (DC), Houston, Huntsville, Cocoa Beach, Colorado Springs and Los Angeles.

Services include:

- Commercial market-driven space systems configuration analysis
- Requirements analysis and payload concept definition
- Project and design feasibility studies
- Space systems life-cycle cost analysis
- Space systems logistics planning and supportability analysis
- Space and ground systems operations capability development and management

Contact: Henry J. Pierce, Senior Associate
Space Systems Division
Booz-Allen & Hamilton, Inc.
4330 East West Highway
Bethesda, MD 20824
(301) 951-2940

Business Communications Company, Inc.

Business Communications Company, Inc. is a full-service technical market research firm that specializes in advanced technology areas including aerospace materials (metals, intermetallics, ceramics, polymers, carbon and composites), advanced optics, sensors, detectors, lasers, electronics, advanced membranes, biotechnology and related industries. BCC provides off-the-shelf multi-client technical/economic studies, as well as custom-designed studies.

Contact: Robert Butler, Director of Operations
Business Communications Company, Inc.
25 Van Zant Street
Norwalk, CT 06855
(203) 853-4266, Fax (203) 853-0348

The Center for Space and Advanced Technology (CSAT)

CSAT was founded to "promote U.S. and Free World leadership in the development and application of advanced technology."

The organization is divided into two principal divisions. CSAT's Strategic, Technical and Business Development Division supports a variety of government, university and commercial clients. CSAT's Engineering and Science Services Division provides technical support services.

Commercial space services include:

- Policy analysis
- Business planning
- Technologies evaluation
- Financial and market analysis
- Strategic programs and advanced planning
- Program management and analysis support

Discipline areas include:

- Engineering
- Life sciences
- Microgravity sciences
- Earth sciences
- Physical sciences
- Information sciences

Contact: Richard Sade or Kim Ellsworth
The Center for Space and Advanced Technology
9302 Lee Highway, Suite 1200
Fairfax, VA 22031
(703) 385-1660

Commercial Space Archives

The Commercial Space Archives is a Space Foundation project established to develop and operate a library of key documents relevant to the development and progression of the commercial space industry, across a broad range of markets. Housed at Virginia's Center for Innovative Technology, the public may access the archival collection of business plans, market reports, congressional hearings, policy statements and corporate reports that have had an impact on the industry.

The Space Foundation is a non-profit corporation headquartered in Washington, DC, that serves a forum through which the business, aerospace industry, government and academic communities meet to discuss the development of commercial space enterprises. The Foundation is the parent organization of the worldwide network of space business roundtables.

Contact: Jeffrey Manber, Executive Director
The Space Foundation
P.O. Box 27017
Washington, DC 20038
(202) 347-2414

Commercial Space Group of KPMG Peat Marwick

The Commercial Space Group supports U.S. and international commercial and government clients with business and financial consulting services. The consulting practice is based on an understanding of the technologies and issues facing each of the primary space technology areas: materials processing, communications, transportation, life sciences, remote sensing and space infrastructure. Services range from strategic planning, operations management and market research to financial analysis, cost management and price analysis.

Located in Washington, DC and Houston, TX, the Commercial Space Group assists federal institutions, academia and industry including emerging entrepreneurial companies and members of the Fortune 500.

Contact: Frank DiBello
KPMG Peat Marwick
2001 M Street, NW
Washington, DC 20036
(202) 467-3098

Conatec, Inc.

Conatec, Inc. provides launch vehicle technical services.

Launch Vehicle/Operations Engineering:

- Mission planning
- Mission integration
- Mission analyses
- Configuration management
- Design and design assessment
- Trajectory and performance analyses
- Aerodynamic analyses
- Thermal analyses
- Safety analysis
- Risk assessment
- Reliability analysis
- Flight and test data evaluation

Launch Vehicle/Operations Technical Services:

- Specifications preparation
- Interface requirements/control documents
- Procedures assurance/quality control
- Assembly
- Integration
- Test coordination
- Flight safety documentation (for expendable launch vehicles and Shuttle)
- Launch operations
- Cost estimating

Contact: Wayne H. Montag
Conatec, Inc.
5900 Princess Garden Parkway, Suite 105
Lanham, MD 20706
(301) 552-1088

Cost, Inc.

Cost, Inc. provides independent cost estimates and cost model development. These include proprietary space system cost models for instruments, spacecraft platforms/buses and mission integration. Models are based on many data points and include independent and objective resource analysis. Parametric models provide fast response.

Consulting services include:

- Cost estimation
- Cost model development
- Cost-engineering trades
- Cost-effectiveness analysis
- Design-to-cost analysis
- Program analyses
- Survey research
- Proposal preparation
- Budget preparation
- Cost analysis training

Contact: Don Strope, President
Cost, Inc.
10630 Little Patuxent Parkway, Suite 329
Columbia, MD 21044
(301) 997-0483

Creative Consulting for the Space Program

Creative Consulting offers a creative approach to technical and scientific information issues and projects.

Services Include:

- Strategic planning for information packages and programs
- Research studies on issues related to space policy, commercial space development, space sciences, technology and international commercial space activities
- Marketing communications – strategic planning and development
- Liaison/coordination – for NASA, industry and academia
- Publication management – form, design and content development; writing, editing and production for publications, reports and brochures
- Conference management and design

Contact: Paula Korn, Principal
Creative Consulting for the Space Program
490 M Street SW, W305
Washington, DC 20024
(202) 479-0025

Early Signals

Commercial Space Services Include:

- Strategic management
- Trend analysis
- Management training workshops
- Research on aerospace issues

Contact: Lena Lupica, President
Early Signals
214 9th Street, NE
Washington, DC 20002-6216
(202) 547-5751

The Egan Group

Commercial Space Services Include:

- Liaison/coordination
- Business planning
- Financial analysis/marketing
- Market study and analysis
- Policy formulation
- International activities

Contact: John J. Egan, President
The Egan Group
1701 K Street, NW, 12th Floor
Washington, DC 20006
(202) 775-0720, Fax (202) 293-1408

E'Prime Aerospace Corporation

Launch Vehicle Services:

- Launch vehicle selection and integration
- Operations planning
- Mission/orbit/trajectory analysis and reviews

Payload Services:

- Payload integration and spacecraft checkout
- Ground support equipment

Range Services:

- Range support planning and coordination
- Data reduction

Other Services:

- Payload/launch vehicle cost studies
- Site selection studies

Contact: E'Prime
P.O. Box 792
Titusville, FL 32781
(407) 269-0900

Futron Corporation

Futron is a diversified technology and management services company, supporting government and industry with a variety of services related to the planning, development and implementation of space flight systems. The professionals at Futron have extensive experience with the commercial space program and NASA's supporting infrastructure.

Space systems engineering and commercial development services include:

- Strategic and program planning
- Mission planning and development
- Technology cost assessments
- Systems engineering and integration
- Policy studies
- Project management training
- Organizational development

Contact: Joseph Fuller, Jr., President
Futron Corporation
7315 Wisconsin Avenue, Suite 400W
Bethesda, MD 20814-3202
(301) 657-7732

Geostar Corporation

The Geostar Corporation is a mobile satellite communications company which provides radiodetermination satellite service (RDSS), a position location and two-way messaging service. These services are provided primarily to mobile vehicles, such as trucks, aircraft and boats, but also can be used in fixed site applications as well. This service allows the headquarters of a fleet of vehicles to monitor the position of its fleet and to communicate with it. The system consists of vehicle-mounted equipment, satellite relays, a central ground station and terrestrial telecom links connecting Geostar to a customer's headquarters. It is being used for both commercial and governmental transportation needs.

Operational Characteristics

Ground station uplink frequency:	6 GHz
Ground station downlink frequency:	4.2 GHz
User uplink:	1610-1626.6 MHz
User downlink:	2483.5-2500 MHz
Information rate:	1.2 kb/sec
Modulation:	BPSK/Spread Spectrum
Spread Ratio:	30 dB
Message unit:	100 alphanumeric characters
Message time:	10-15 seconds

Contact: Geostar Corporation
1001 22nd Street, NW, Suite 500
Washington, DC 20037
(202) 887-0870

Gulton Data Systems

Gulton Data Systems provides space flight electronics including command decoding, data acquisition, timing systems, power conditioning and special processing. Available systems include both standard and custom designs for satellites, spacecraft, experiments and launch vehicles.

Gulton's engineering and manufacturing capabilities are available on a subcontract basis, including:

- Electrical design and analysis
- Mechanical design and analysis
- Redundant systems
- Radiation hard systems
- Electronic assembly
- Printed circuit board manufacture (MIL-P-55110)
- Machining
- Electronic parts testing and screening

Contact: Tim Turner, Director of Program Development, Gulton Data Systems
6600 Gulton Court, NE
Albuquerque, NM 87109
(505) 345-9031

Horizon Aerospace

Horizon Aerospace offers aerospace engineering and contract management services to NASA and prime contractors, with facilities in the immediate area of NASA's Johnson Space Center. Horizon capabilities cover program/project management, systems engineering and integration, flight and ground operations, simulations and training, and research and technology assessment. Horizon manages and conducts trade and analytical studies, and is expert at forming and leading teams and subcontractors to bring recognized expertise to bear on projects and programs.

Horizon's services include:

- Aerospace management services
- Systems engineering and integration
- Flight and ground operations
- Simulation and training
- Research and technology

In addition, Horizon provides computer system and software services, Computer Aided Logistics Systems (CALS), marketing services, visuals/graphics, and safety and quality assurance.

Contact: Neal Jackson
Horizon Aerospace
18333 Egret Bay Blvd., Suite 300
Houston, TX 77058
(713) 333-5944, Fax (713) 333-5949

Information Universe

Space Information Services include:

- Research capabilities
- Custom PC databases
- Information summaries and indexes
- PC information systems
- Editorial assistance for manuscripts and publications

Small and medium size companies that do not have library or information center staff will find these services very useful. Start-up companies also will find business and technical research services available. Indexes can be produced for a variety of publication types including book indexes, newsletters, magazines, document databases, reference databases and proceedings.

Contact: Linda Kenny-Sloan, President
Information Universe
300 Carlyle Ave.
Belleville, IL 62221
(618) 233-4659

Infospace, Inc.

Infospace provides marketing support, research and weekly and quarterly publications that provide insight into procurement opportunities and activities at NASA/Johnson Space Center.

Contact: Walter Salyer, President
Infospace, Inc.
P.O. Box 58564
1199 NASA Road One, Suite 210
Houston, TX 77258
(713) 480-8849

Integrated SpaceSystems

Integrated SpaceSystems specializes in manned space systems R&D and offers consulting services which include human factors engineering, crew quarters and habitat design and EVA/IVA operations analysis and planning. Our Model and Mockup Group specializes in the design and fabrication of high fidelity representations of aerospace technology, lunar surface topographic models, crew quarters and workstation mockups, and neutral buoyancy mockups. We also provide end-to-end planning and arrangements for spacesuited neutral buoyancy simulations.

Services Include:

- Outfitting of spacecraft interiors
- Space human factors environmental design and engineering
- Space construction operations research and technology R&D
- Zero-G and partial-G anthropometric studies
- Manned space systems technology R&D
- EVA and IVA operations research and planning
- Design and fabrication of aerospace models and mockups
- Neutral buoyancy mockups/trainers and simulations

Contact: Andrew W. Daga, President
Integrated SpaceSystems
P.O. Box 156
Collegeville, PA 19426-2904
(215) 489-7282, Fax (215) 489-4766

International Technology Underwriters (INTEC)

Space and other space-related insurance coverage includes:

- Large and small ELV and Shuttle launch coverage
- Spacecraft initial operations coverage
- Spacecraft on-orbit life coverage
- DOT-required third-party liability and government property damage coverages
- NASA-required Shuttle third-party liability coverage
- NASA-required KC-135 flight program coverages

Contact: Peter M. Stark
Director, Advanced Space Programs
International Technology Underwriters
4800 Montgomery Lane, 11th Floor
Bethesda, MD 20814
(301) 654-8585, Fax (301) 654-7568

Interstel Inc.

Interstel Inc. provides Payload Integration and Engineering Support Services, including:

- Project plans and work breakdown structures
- Flight readiness verification plans and procedures
- Payload integration plans
- Instrument integration plans
- Interface control documents
- Flight ground safety data packages
- Interface requirements definition
- Ground operations and servicing requirements documents
- Configuration management
- Schedule and cost control
- Mechanical design and analysis

Contact: John Ralph, Program Manager
Interstel Inc.
9470 Annapolis Road Suite 401
Lanham MD 20706
(301) 459-7088, Fax (301) 459-1599

Johnson Engineering Corporation

Johnson Engineering Corporation provides Computer Illustrated Drawing (CID) software used to prepare the Crew Compartment Configuration Drawing (CCCD) for each Shuttle and Spacelab launch. All loose provisions stowed in the middeck or flight deck are listed in a bill of materials illustrated in three-dimensional pictorial views showing where they are stowed with callouts. The CAD workstation operator can create and update the drawings, DCN's and bill of materials using this CAD software and large database management system. User licenses and support services are available to commercial researchers needing to optimize the stowage of supplies in limited volumes. CID software can be used with VMS operating systems on DEC mini or microVAX computer equipment. Graphic terminals are either Megatek or Evans and Sutherland.

Habitability design services also are available, including studies and/or designs of crew cabins for people to live and work effectively in partial gravity environments. The technical approach is used to prepare concept sketches, color renderings, scale models and full-scale mockups until the design is mature. Trainers are provided for crew training in one-gravity, KC-135 aircraft and underwater neutral buoyancy. The habitability features usually include the general arrangement, workstations, sleep compartments, galley, personal hygiene, waste management, ward room, health maintenance equipment, exercise equipment, personal provisions, entertainment and stowage compartments. The same CAD software (named DASH) as above is used to optimize the stowage of loose crew provisions in stowage compartments.

Contact: Johnson Engineering Corporation
3055 Center Green Drive
Boulder, CO 80301-5406
(303) 449-8152

MARCOR

MARCOR is a multi-disciplinary space technology commercialization and applications firm specializing in analysis, planning and start-up financing of new space ventures. Clients include private firms (including aerospace firms) and government agencies.

MARCOR is pursuing new ventures in satellite communications, remote sensing and digital mapping. The company is working in the area of satellite sound broadcasting where it holds a 50% interest in the newly formed Satellite CD Radio, Inc., a company dedicated to flying the first commercial satellite dedicated to providing CD-Quality radio on a nationwide basis.

MARCOR services include:

- Market assessment and development
- Regulator analysis
- System design and project management
- Business plan development and financing
- Strategic planning

Contact: Martin Rothblatt, President
MARCOR
Techworld Plaza
800 K St. NW, Suite 750
Washington, DC 20001
(202) 408-0080, Fax (202) 408-0925

Netrologic, Inc.

Netrologic provides consulting and research on the application of neural networks to solving complex problems for government and industry. Projects for NASA mission management functions include neural networks trained on rocket engine data (Shuttle main engine) to perform engine health monitoring, RF measurements of cryogenic tanks to determine fuel mass and engine control valve time signatures to recognize faults and perform value identification.

Additional experience includes adaptive image compression on multi-spectral imagery (200 spectral bands); dynamic emitter recognition using neural networks; investigation of the application of genetic algorithms to specify topologies for neural networks from the parameters characterizing a problem; duplication of the performance of an air traffic controller (LAX TRACON); and development of an intelligent tutor for the Navy's sonar operators and image compression using Fractals and Group Representation Theory.

Contact: Dan Greenwood, President
Netrologic, Inc.
5080 Shoreham Place, Suite 201
San Diego, CA 92122
(619) 587-0970, Fax (619) 458-1624

Optical Research Institute, Inc.

Optical Research offers services in the design, construction, operation and consultation in and of advanced microgravity optical measurement systems, specializing in KC-135 low-gravity simulation measurements and experiments. Measurement techniques include Schlieren, shadowgraph, interferometric and holographic systems. Applications include space hardware development and basic research in microgravity processes.

Contact: Robert B. Owen, Chief Scientist
Optical Research Institute, Inc.,
P.O. Box 17382
Boulder, CO 80308-7382
(303) 441-9027

Precision Aerospace Marketing and Fabrication (PAMCO)

PAMCO, a division of Space Industries, Inc., provides state-of-the-art marketing and fabrication capabilities for spaceflight and prototype hardware.

Contact: Roger L. Pulley, Manager
PAMCO
12610 Old Galveston Road
Webster, TX 77598
(713) 488-4208

W.L. Pritchard & Co.

Planning, design and consulting services in satellite and telecommunications systems include:

- Systems design and engineering
- Economic analysis
- Market research
- Appraisals
- Demand forecasts
- Technology assessment
- Regulatory submissions

Contact: W.L. Pritchard
W. L. Pritchard & Co.
7315 Wisconsin Ave., Suite 520-E
Bethesda, MD 20814
(301) 907-7070

David L. Reed

Systems Engineering and Analysis services include:

- Space systems design and analysis
- Orbital mechanics
- Trajectory analysis
- Navigation location and analysis
- Missile dynamics

Contact: David L. Reed
14649 Stonewall Drive
Silver Spring, MD 20905
(301) 384-2419

Rizenthor

Rizenthor specializes in graphic design for the space industry. Workscope includes presentations, logos and symbolic representation of complex data, 35 mm photography using high color saturation techniques and backgrounds for home, office and laboratory environments.

Contact: Robert Anthony Foster
Rizenthor
721 North Alfred Street, Suite 108
Los Angeles, CA 90069
(213) 651-1024

SaraTech Finance, Inc.

A subsidiary of the Center for Space and Advanced Technology, SaraTech provides financial services and capitalization support to emerging growth ventures dedicated to the application of advanced technology.

Commercial Space Services include:

- Financing and capital sourcing
- Capital structure planning
- Business plan development
- Business valuation
- Organizational design
- Due diligence support

Contact: Jeff Struthers or Anne Renouf Headley
SaraTech Finance, Inc.
9302 Lee Highway, Suite 1200
Fairfax, VA 22031
(703) 385-1660

Satellite Mapping Corporation, Inc.

Satellite Mapping Corporation (SMC) specializes in the use of Landsat, SPOT and complementary data sources for a wide variety of geographic information products in both the domestic and international market. SMC has particular expertise in the use of commercially available, remotely sensed data for information collection and analysis in a wide variety of fields, from agricultural and urban development to military threat assessment and contingency planning. SMC provides not only studies and analyses of remote sensing data, but also develops custom-designed image analyses and mission rehearsal workstations to meet unique geographic database requirements.

Contact: Douglas N. Grize, President
Satellite Mapping Corporation, Inc.
8229 Boone Boulevard, Suite 800
Vienna, VA 22182
(703) 790-0893

W.J. Schafer Associates, Inc.

W.J. Schafer Associates, Inc. offers critical, decision-making information for making major commitments in the research, development and implementation of new technologies in defense, space, energy and the environment. The group's strong benefit is providing program managers with access to over 200 leading experts in a broad range of technical disciplines who provide an unequalled pool of talent to help manage and execute high technology programs. Key components of the firm's approach are concept development, technology assessment, systems analysis and programmatic support.

WJSA has tools to provide system and sub-system analysis to help clients meet performance and schedule requirements. These tools include modeling and simulation capabilities from small models to large, detailed Monte Carlo simulations, encompassing cost, risk, life cycle and schedule considerations. WJSA maintains a fully-equipped research laboratory where proof-of-principle experiments and hardware development activities are performed. Services also include verification of scientific concepts, investigation of technological potential, and design and construction of laboratory prototypes. WJSA has 14 offices nationwide.

Contact: Phil Mace
Director, New Business Development
W. J. Schafer Associates, Inc.
1901 North Ft. Myer Drive, Suite 800
Arlington, VA 22209
(703) 558-7900

Science Applications International Corporation (SAIC)

SAIC provides mission planning, science support, Systems Engineering & Integration, data management, sensor development, propulsion management, tracking, telemetry and command, and EVA/Servicing.

Contact: Ron G. Crawford
Manager, Space Programs
Science Applications International Corp.
1710 Goodridge Drive, Mail Stop 2-4-3
McLean, VA 22102
(703) 556-7019

Source Translation & Optimization (STO)

STO maintains a database of information on over 10,000 computer programs available to the public from the government. STO helps companies acquire and reuse software from various agencies, in particular, NASA, DOD and DOE. Software is available in Fortran, C and Ada for personal computers, workstations and mainframes.

Space technology related software available includes:

- Aeronautics
- Atmospheric
- Remote sensing
- Life support
- CAD/CAM/CAE
- Expert systems
- Propulsion
- Transportation
- Spacecraft and aircraft design
- Materials processing
- Fluid and structural mechanics

Contact: Gregory Aharonian
President
Source Translation & Optimization
P.O. Box 404
Belmont, MA 02178
(617) 489-3727

Space Business Research Center

Specializing in forecasts and issues management, Space Business Research Center presents seminars, workshops and conferences that are custom-tailored to the client's needs. The Center also provides:

- Primary, secondary and proprietary research
- Data services of analysis and interpretation
- Publications, including executive summaries and detailed industry and market reports
- Economic analysis and market forecasts

Contact: Space Business Research Center
University of Houston-Clear Lake
Houston, TX 77058-1090
(713) 283-3320, Fax (713) 283-3810

Space Industries, Inc.

Intelligent Systems provides consulting, software development, and basic research services to enhance the capabilities to access, manipulate and interpret information for aerospace and commercial applications. By applying extensive in-house expertise, understanding and insight into the problems and complications of space operations and logistics, Space Industries develops innovative approaches in areas such as:

- Decision support systems
- Scheduling systems
- Project management tools
- Expert systems
- Telescience applications
- Operations research
- Data acquisition, monitoring and control

In addition to development for space applications, Intelligent Systems also brings the high technology of space to the development of state-of-the-art approaches for customers with Earth-based uses.

Contact: Clifford R. Kurtzman, Ph.D.
Manager, Intelligent Systems
Space Industries, Inc.
711 W. Bay Area Blvd., Suite 320
Webster, TX 77598-4001

Spaceflight Insight Services

Consulting services include:

- Soviet space technology
- US/USSR interfacing
- Manned spaceflight operations
- Historical/archival data access
- Spaceflight and society issues
- Lecture programs

Contact: James Oberg
Route Two, Box 350
Dickinson, TX 77539
(713) 337-2838

Spire Corporation

Spire Corporation provides surface modification services for space materials including:

- Ion-assisted dielectric coating
- Beryllium and other metal coating
- Ion implantation
- Ion-assisted texturing

Applications:

- Ram oxygen protection
- Radiation resistance
- Optical baffles and mirrors
- Friction reduction and control
- Thermal control

Contact: Ward Halverson
Director/Thin Film Division (for space solar cells, contact Robert G. Wolfson)
Senior Vice President
Spire Corporation
Patriots Park
Bedford, MA 01730
(617) 275-6000

Technology Transfer Specialists, Inc.

Technology Transfer Specialists, Inc. processes commercial space information and creates paper (newsletters, brochures, manuals, tech notes, tech briefs, etc.) and paperless (linear videotape, computer-based training, computer simulation, computer-generated animation, laser video disc, interactive multimedia, etc.) mediums for transfer of commercial space information.

Contact: S. Carl Ahmed, CEO & President
Technology Transfer Specialists, Inc.
Highway A-1-A, Satellite Beach
P.O. Box 03-4075
Indialantic, FL 32903-0975
(407) 777-6777

United States Aviation Underwriters, Inc.

Satellite and other space-related risks insurance coverage for owners, operators, users and manufacturers. Coverage areas include:

- Launch
- In-orbit
- Launch liability
- Products liability

Contact: C.T.W. Kunstadter, Senior Vice President
United States Aviation Underwriters, Inc.
One Seaport Plaza
199 Water Street
New York, NY 10038
(212) 952-0100, Fax (212) 747-0840

Walker Communications

International consulting in marketing and public relations for commercial space companies, ventures and products. Services include:

- Market research and analysis
- Marketing programs
- Public relations campaigns
- Media relations
- Article placement
- Press releases/newsletters
- Product introduction
- Special events and promotion

Contact: Pat Walker
Walker Communications
1150 Marina Village Parkway, Suite 104
Alameda, CA 94501-1043
(415) 865-5157, Fax (415) 386-8334

Wallwork-Warner

Wallwork-Warner provides commercial space, NASA and DOD space business development services including:

- Market entry strategy
- Program plans
- External environment/trends
- Strategic plans
- Proposal development
- Economic evaluation

Contact: David Wallwork, Partner
Wallwork-Warner
720 Creek Road
Downingtown, PA 19335
(215) 873-0669

Chapter 23: Government and Academia

In 1958, NASA was established as the primary agency for all civil research and development in space. Since then, with the emerging developments of commercialization, technology, disciplines and global change, there now are several federal and academic organizations that are active in, or supportive for, commercial activities in space. Many of these organizations offer technical assistance, equipment and facilities, technology transfer, policy and regulatory control, as appropriate.

This chapter surveys many of the various agencies, organizations and academic institutions that play an active role in the commercial development of space.

National Aeronautics and Space Administration (NASA)

Within NASA, the Office of Commercial Programs takes the lead role in developing and implementing programs that will stimulate and sustain U.S. commercial interest and investment in commercially oriented, space-related R&D activities. NASA has no responsibility or authority to regulate private commercial space activities. However, NASA does set the terms for all use of the Space Shuttle.

Whatever the market entity, private commercial customers must abide by NASA's rules and regulations regarding payment, scheduling, liability, insurance, safety and technical standards and policy. NASA also controls much of the equipment, technology and facilities that are important to the commercialization of space. NASA thereby dictates price, terms and conditions when making these available for use. The terms and conditions for sale and use of NASA-derived technology reflects official regulatory policy.

Opportunities to fly space experiments are arranged through the Office of Space Flight, where NASA has set aside flights on the Shuttle, expendable launch vehicles and sounding rockets to support private-sector research with the potential for commercial development. Shuttle flights are available primarily through Joint Endeavor Agreements and the Centers for the Commercial Development of Space. In an effort to stimulate and encourage the private sector to team with NASA for the purpose of commercial enterprise, its Office of Commercial Programs actively recruits researchers and entrepreneurs to participate in industry-government partnership agreements and industry-academic consortia.

The Commercial Programs Advisory Committee (CPAC) addresses critical policy issues and contributes in shaping NASA's commercial development strategic planning. In 1990, NASA Administrator Richard H. Truly established the Space Commerce Steering Group, to provide a high-level overview and coordinating mechanism for commercial applications of space technology throughout the Agency.

NASA Field Centers

NASA facilitates access to its resources, personnel and information through a representative contact for commercial space development in each of its eight field centers nationwide. The services available through these centers include information, transportation, payload processing and integration, program planning, experiment testing and equipment development.

Elizabeth A. Inadomi
Mail Code 223-3
NASA/Ames Research Center
Moffett Field, CA 94035
(415) 694-6472

Donald S. Friedman
Mail Code 702.0
NASA/Goddard Space Flight Center
Greenbelt, MD 20771
(301) 286-6242

Mark Nolan
Mail Code EA-111
NASA/Johnson Space Center
Houston, TX 77058
(713) 283-5320

Robert L. Butterfield
Mail Stop PT-PMO-A
NASA/Kennedy Space Center
Kennedy Space Center, FL 32899
(407) 867-3017

Fred Allamby
Mail Stop 356
NASA/Langley Research Center
Hampton, VA 23665
(804) 864-3788

Harv[illegible]nwartz
MS 3[illegible]
NASA/Lewis Research Center
221000 Brookpark Road
Cleveland, OH 44135
(216) 433-2921

Kenneth Taylor
Mail Code PS05
NASA/Marshall Space Flight Center
Huntsville, AL 35812
(205) 544-0640

Chuck Hill
Mail Code HA31
Building 1100, Room 230
NASA/Stennis Space Center, MS 39529
(601) 688-2047

William T. Callaghan
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-0865

Centers for the Commercial Development of Space (CCDS's)

The Centers for the Commercial Development of Space (CCDS's) were initiated to stimulate high technology research which takes advantage of the characteristics of space; and to lead in the development of new products and services which have commercial potential or contribute to possible new commercial ventures. More than 175 U.S. firms are associated with the operating CCDS's as business incubator settings for new research. NASA funds initial start-up costs on a three-phase basis.

NASA presently sponsors sixteen CCDS's, which have grown as unique sources for partnerships in technology development, experiment design, business planning and basic research in seven discrete discipline areas. The centers represent consortia of university, industry and government involved in early research and testing stages of potentially viable products or services. A CCDS Management Operations Working Group serves as a coordinating body for collaborative efforts and program planning. (For an in-depth description of each CCDS, refer to Chapter 5.)

Ramesh Jain, Director
Space Automation and Robotics Center (SPARC)
P.O. Box 8618
Ann Arbor, MI 48107
(313) 994-1200 x2457

John Bollinger, Director
Wisconsin Center for Space Automation & Robotics (WCSAR)
University of Wisconsin/Madison
1357 University Ave.
Madison, WI 53715
(608) 262-5524

John Bossler, Director
Center for Mapping
Ohio State University
1216 Kinnear Road
Columbus, OH 43212
(614) 292-6642

Centers for the Commercial Development of Space (continued)

George May, Director
Space Remote Sensing Center
Bldg. 1103 - Suite 118
NASA/Stennis Space Center, MS 39529
(601) 688-2509

Marvin Luttges, Director
BioServe Space Technologies
University of Colorado/Boulder
Campus Box 429
Boulder, CO 80309
(303) 492-7613

Wesley Hymer, Director
Center for Cell Research (CCR)
Pennsylvania State University
204 S. Frear Laboratory
University Park, PA 16802
(814) 865-2407

Charles Bugg, Director
Center for Macromolecular Crystallography (CMC)
University of Alabama/Birmingham
THT-Box 79, University Station
Birmingham, AL 35294
(205) 934-5329

Frank Jelinek, Director
Advanced Materials Center/Battelle
505 King Ave.
Columbus, OH 43201
(614) 424-6376

William Wilcox, Director
Center for Commercial Crystal Growth in Space
Clarkson University
Old Main, Room 126
Potsdam, NY 13676
(315) 268-2336

Charles Lundquist, Director
Consortium for Materials Development in Space
(CMDS)
University of Alabama/Huntsville
Research Institute Building
4701 University Drive
Huntsville, AL 35899
(205) 895-6620

Tony Overfelt, Director
Center for Space Processing of Engineering Materials
Vanderbilt University
Box 6309, Station B
Nashville, TN 37235
(615) 322-7054

Alex Ignatiev, Director
Space Vacuum Epitaxy Center (SVEC)
University of Houston
Science & Research Bldg. 1
4800 Calhoun Road
Houston, TX 77204
(713) 749-3701

Alton Patton, Director
Center for Space Power (CSP)
Wisenbaker Engineering Research Center
Room 223
Texas A&M University
College Station, TX 77843
(409) 845-8768

Raymond Askew, Director
Center for the Commercial Development of Space
Power & Advanced Electronics
Space Power Institute
Auburn University
231 Leach Center
Auburn, AL 36849
(205) 844-5894

George Garrison, Director
Center for Advanced Space Propulsion (CASP)
University of Tennessee Space Institute
UT-Calspan Center for Aerospace Research
P.O. Box 850
Tullahoma, TN 37388
(615) 454-9294

Eric Baer, Director
Center for Materials for Space Structures
Case Western Reserve University
School of Engineering
10900 Euclid Ave.
Cleveland, OH 44106
(216) 368-4203

Small Business Innovation Research Program

The Small Business Innovation Research (SBIR) Program enhances the role of small businesses in meeting NASA's requirements for aerospace technology while stimulating innovation and commercialization in the private sector. In accordance with the Small Business Development Act of 1982, NASA allocates 1.5% of its R&D budget for SBIR. To participate, small businesses must be independently owned and organized for profit, be located principally in the U.S., be owned at least 51% by U.S. citizens or permanent resident aliens, and employ not more than 500 persons. Each year, NASA solicits proposals for innovations in selected technical areas. Highly rated proposals receive six-month, Phase I contracts for about $50,000. Successful projects can receive Phase II contracts with funding up to $500,000. Phase III, commercialization and end-use development of SBIR products, is funded by the private sector or other non-SBIR sources. The program is managed through the headquarters SBIR office and SBIR representatives at each of the NASA field centers.

Contact: SBIR Program Manager
NASA Headquarters/Code CR
Washington DC 20546

Technology Transfer and Utilization

By participating in a number of new cooperative ventures and implementing new initiatives, NASA's nationwide technology transfer network is growing, bringing NASA-developed and space-derived technologies to the public and private sectors, particularly for the development of new products, processes and services. With the addition of seven new affiliates, this network now extends into 40 states across the country. Spinoffs, in such diverse areas as transportation and medicine, have generated far-reaching social and economic benefits for the nation. NASA also supports strong technology utilization and application programs. These include:

- Field Center Technology Utilization officers, who manage center participants in regional technology utilization activities.
- Industrial Applications Centers (IAC's), which provide information retrieval services and assistance in applying technical information relevant to user needs.
- Industrial Applications Centers Affiliates, which are state-sponsored business or technical assistance centers, providing access to NASA's technology transfer network.
- Computer Software Management and Information Center (COSMIC), which offers government-developed computer programs adaptable to secondary use (see page 251).
- Technology Application Teams, which work with public agencies and private institutions in applying aerospace technology to solution of public problems.

Industrial Application Centers (IAC's)

F. Timothy Janis, Director
Aerospace Research Applications Center
Indianapolis Center for Advanced Research
611 N. Capitol Ave.
Indianapolis, IN 46204
(317) 262-5036

Dickie Deel, Director
Central Industrial Applications Center
Rural Enterprises, Inc.
P.O. Box 1335
Durant, OK 74702
(405) 924-6822

Paul A. McWilliams, Executive Director
NASA/Industrial Applications Center
823 William Pitt Union
Pittsburgh, PA 15260
(412) 648-7000

Radford G. King, Director
NASA/Industrial Applications Center
Research Annex, Room 200
University of Southern California/Los Angeles
3716 South Hope Street
Los Angeles, CA 90007
(213) 743-6132

Daniel Wilde, President
NERAC, Inc.
One Technology Drive
Tolland, CT 06084
(203) 872-7000

H. Lynne Reese, Director
Science and Technology Research Center
P.O. Box 12235
Research Triangle Park, NC 27709
(919) 549-0671

Stanley A. Morain, Director
Technology Applications Center
University of New Mexico
2808 Central, S.E.
Albuquerque, NM 87131
(505) 277-3622

Technology Transfer and Utilization (continued)

Industrial Application Centers (IAC's) (continued)

J. Ronald Thornton, Director
NASA/Southern Technology Applications Center
Progress Center, Box 24
One Progress Blvd.
Alachua, FL 32615
(904) 462-3913

William R. Strong, Director
NASA/UK Technology Applications Program
10 Kinkead Hall
University of Kentucky
Lexington, KY 40506
(606) 257-6322

John Hubbell, Director
NASA/SU Industrial Applications Center
Southern University
P.O. Box 9737
Baton Rouge, LA 70813-9737
(504) 771-4950

Aerospace Research Applications Center

The Aerospace Research Applications Center provides Technology Transfer Surveys (TTS), involving the engineering/scientific application of existing technology (knowledge). TTS's are useful to ascertain the potential viability of novel/proposed commercial space projects. A typical study requires 10-12 weeks.

Contact: F. Timothy Janis, Director
Aerospace Research Applications Center
Indianapolis Center for Advanced Research
611 N Capitol
Indianapolis, IN 46204
(317) 262-5036

NERAC, Inc.

NERAC, Inc. is a not-for-profit service working in cooperation with NASA to promote the dissemination and utilization of global technologies. NERAC's resources include two mainframe computers, over 120 major databases in all technical and scientific disciplines, a large staff of technical experts, document retrieval services and liaison to the 400+ Federal Laboratories.

Contact: Nan R. Cooper
Manager, Communications
NERAC, Inc.,
One Technology Drive,
Tolland, CT 06084
(203) 872-7000

Science and Technology Research Center (STRC)

The Science and Technology Research Center (STRC) provides scientific and technical information services and engineering assistance to industry and university research programs throughout the southeastern United States. Utilizing a large number of remote online and locally maintained machine-readable databases, the Center's basic objective is to help industry upgrade products and improve processes through the application of new technology documented in worldwide published and unpublished literature from governmental sources. There is broad coverage in all fields of the social sciences, science, technology, engineering and business.

Machine-readable copies of the Institute of Textile Technology File and World Textile Abstracts are maintained. The Center also has access to over 500 available microfiche of NASA's Scientific and Technical Aerospace Reports (STAR). Databases accessed online by STRC include those carried by DIALOG Information Services, Inc., BRS Information Technologies, U.S. National Library of Medicine, NASA/RECON and others. Search services available include retrospective searches, current awareness and standard interest profiles, supplemented by manual searching and the provision of complete documents or pertinent citations.

Additional activities include in-depth studies, reference and referral, seminars, workshops and conferences. As part of the NASA Industrial Applications Centers' Network, the Research Center receives support from NASA's Technology Utilization Division. The Center also is part of the North Carolina Department of Economic and Community Development.

Contact: Tony Pollard, Marketing Manager
Science and Technology Research Center
P.O. Box 12235
Research Triangle Park, NC 27709-2235
(919) 549-0671

Southern University Industrial Applications Center

Information Services and Technical Assistance includes:

- Literature searches
- Marketing research
- Technical activities
- Demographic trends
- Patent information
- Government procurement
- NASA technology

Contact: John Hubbell, Director
NASA/Southern University Industrial Applications Center
P.O. Box 9737
Baton Rouge, LA 70813-9737
(504) 771-4950

Department of Transportation

Space activities of the Department of Transportation (DOT) are focused in the Office of Commercial Space Transportation, established to foster the creation and growth of the expendable launch vehicle (ELV) industry, issue launch licenses and administer required mission and safety reviews. Authorized by the Commercial Space Launch Act of 1984, this office is mandated to license and regulate U.S. commercial space launch activities in a manner which protects both public safety and government interests, and to encourage the development of commercial launch capabilities. Toward this end, the Office of Commercial Space Transportation acts as a regulator and a service provider for launch operators.

This office also supports the Commercial Space Transportation Advisory Committee, which assisted in negotiating a Model Launch Range Agreement for commercial launches from Air Force ranges in 1987, and continues to oversee issues of concern for the development of the commercial launch services industry at large.

The Office of Commercial Space Transportation is committed to the development of an efficient, safe, low-cost space launch industry. Low cost and reliable access to space is the foundation on which many other commercial applications of space technology, such as microgravity research and remote sensing, are based. Among its many responsibilities, this office:

- Provides a single point of contact for companies acquiring launch vehicles for commercial purposes
- Serves as a government focal point for the commercial ELV industry
- Establishes a manifest for payloads and vehicles

Licensing
The Office of Commercial Space Transportation provides a variety of services to anyone seeking a license or DOT approval, which is required if offering commercial services that include:

- Preparation and launch of a commercial launch vehicle on an orbital or suborbital trajectory
- Placement of a payload into space aboard an American launched, non-U.S, government vehicle (except for communications and remote sensing payloads, which are covered by FCC and NOAA regulations, respectively)
- Operation of a commercial reentry vehicle
- Operation of a commercial launch site

Consultation
DOT encourages applicants to consult with the Licensing Programs Division at the earliest possible stage of planning for a launch to address issues for preparation, submission and review of applications. The applicant should obtain written summaries of current requirements, DOT's role in determining insurance requirements and license compliance monitoring.

Sponsorship
Companies wishing to use the facilities and services of government launch centers, such as the Air Force Western Space and Missile Center (Vandenberg, CA), may require sponsorship by another government agency to obtain access. DOT provides this service and will assist in establishing points of contact between the company and the government operator.

Insurance
Although usually associated with an actual launch license, DOT offers advance determinations of financial responsibility requirements, if requested, concerning third-party and government property insurance levels. This information may be helpful in planning for future launches, prior to submitting an application.

Contact: Associate Director for Program Affairs
U.S. Office of Commercial Space Transportation
400 Seventh Street SW
Washington DC 20590
(202) 366-5770

Department of Commerce

In 1987, the Secretary of Commerce established the Office of Space Commerce to work with governmental and international organizations in formulating policies to support commercial space development and coordinate the activities of other Department of Commerce (DOC) bureaus affecting space business. This office also conducts outreach activities to keep U.S. companies informed of new prospects in commercial space development, issues of international trade and commerce, and statistics concerning the world market in space industry services and products.

Through the National Oceanographic and Atmospheric Agency (NOAA), the Department of Commerce operates the weather satellite system and oversees LANDSAT operations, managed by the EOSAT Company.

The National Institute of Standards and Technology (NIST) is a resource to industry in areas such as robotics development, which ultimately will be essential to the success of space-based processing, construction and operations.

Other offices active in commercial space developments include the Patent and Trademark Office, the International Trade Administration and the National Telecommunications and Information Administration (NTIA).

Office of Space Commerce

The Office of Space Commerce is the principal unit for the coordination of space-related issues, programs and initiatives within DOC. In this capacity, it promotes private sector investment in space activities by collecting, analyzing and disseminating information on space markets, and by conducting workshops and seminars to increase awareness of commercial space opportunities. It also supports the Secretary of Commerce's Commercial Space Advisory Committee.

The office assists commercial space companies in their efforts to do business with the U.S. Government. It also acts as industry's advocate with the Executive Branch to ensure the government meets its space-related requirements to the fullest extent possible with commercially available goods and services; and works to prevent action that may preclude or deter the commercial sector from conducting those activities, except for reasons of national security or public safety.

The Office of Space Commerce promotes the export of space-related goods and services and represents DOC in the development of U.S. policies and in negotiations with foreign countries, to ensure free and fair trade on the international space market. It also seeks the removal of legal, policy and institutional impediments to space commerce.

While the Office of Space Commerce is not responsible for regulating commercial launch and service providers (as is DOT), or for funding technical research programs (as is NASA), it does, however, represent a full range of business interests in space. For example, the satellite, remote sensing and satellite navigation industries; as well as mobile communications, space-based facilities and the commercial microgravity industries; are addressed in their entirety by either NASA or DOT programs. However, non-technical concerns; such as financing, tort liability, procurement reform, antitrust protection and tax reform; all are critical to emerging space industries and are areas of concern to DOC.

National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST) establishes and maintains national standards of measurement. It also provides measurement services consisting of Calibration Services, Standard Reference Materials and Standard Reference Data that assure traceability to national and international standards. And it provides fundamental physical, chemical, engineering and material data to support national goals in civil, national security and commercial space activities.

NIST supports a wide variety of aeronautical and space programs in areas such as high performance airframe and propulsion materials evaluation, satellite and ground-based antenna calibration, time standards, image analysis methods and hardware, robotics and telerobotics development, high performance computing and networking, data transmission security and calibration of sensors.

As part of its new responsibilities assigned by the Omnibus Trade Act of 1988, NIST is increasing its activities that support transfer of government-developed technology to U.S. industry, and is providing assistance to small business.

NIST's most recent activities include work in the areas of Space Programs Support, High Performance Aerospace Materials, Space Sciences Research, Atmospheric Sciences Research, and Commercial Space Development and Technology Transfer.

Department of Commerce (continued)

National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA) conducts research; gathers, stores and analyzes data about the oceans, atmosphere, space and sun; and applies this knowledge in environmental forecasting and enhancement of knowledge of environmental processes.

These functions are performed by NOAA's National Weather Service, National Ocean Service, National Marine Fisheries Services and Environmental Research Laboratories. The satellite data that is obtained and utilized originates from NOAA's own polar-orbiting (NOAA) and geostationary spacecraft (GOES), which are operated by the National Environmental Satellite, Data and Information Service (NESDIS), and from the satellites of other agencies or governments.

Satellite Data Services Division – A prime source of remote sensing data is available from the Satellite Data Services Division (SDSD) at the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA).

NOAA's Satellite Data Services Division is a unique source of information gathered by a series of Earth-watching spacecraft that began in 1960. The Division receives data (e.g., negatives, film loops, digital data on magnetic tape) for quality control and archiving which are readily accessible for retrospective use. Over 8 million separate images and 100,000 computer compatible tapes are now in archives.

Environmental data files at the Satellite Data Services Division contain imagery from the current polar orbiting (NOAA Series) and Geostationary Satellites (GOES). The Division also maintains magnetic tapes containing digital data from these satellites, representing an important source of information that can be used quantitatively in computerized research and analysis programs. Other satellite digital data has been acquired by the Defense Meteorological Satellite, SEASAT, and the NIMBUS-7 Coastal Zone Color Scanner.

Contact: Satellite Data Services Division
5627 Allentown Road, Room 100
Princeton Executive Center
Camp Springs, MD 20746
(301) 763-8402

National Telecommunications and Information Administration

The National Telecommunications and Information Administration (NTIA) is the principal communications adviser to the President. This DOC bureau develops and coordinates Executive Branch policy in telecommunications and information. NTIA also is responsible for managing the radio spectrum assigned for Federal use and provides technical assistance to other Federal agencies. NTIA plays an important role in helping to develop U.S. policy in space communications.

Information

For information pertaining to any of the above described offices or functions of the Department of Commerce, contact the following individuals:

Office of Space Commerce
Laura Ayers, Associate Director for Special Programs, (202) 377-8125

National Institute of Standards and Technology
Dick Franzen, Chief of the Public Affairs Division, (301) 975-2759

National Oceanic and Atmospheric Administration
Reed Boatwright, Director of the Office of Public Affairs, (202) 377-4190

National Telecommunications and Information Administration
Eileen B. Doherty, Director of Media Relations, (202) 377-1551

Department of Defense

The Department of Defense (DOD) contributes to the development of commercial space technology in such areas as low-cost, lightweight satellites, space robotics, sensors, communications technology and new-technology launch vehicles. Organizations such as the Defense Advanced Research Projects Agency (DARPA) and the Strategic Defense Initiative Organization (SDIO) have become key customers for several space products and services in which many new start-up businesses and small space companies have participated.

DOD exercises authority over and provides invaluable support to many private space ventures. Through the interagency review process, DOD comments on the national security aspects of proposed private space activities and sometimes public safety aspects. The U.S. Air Force controls and operates most of the government launch ranges. In addition, the Air Force is responsible for space traffic and monitoring through the NORAD/Space Command.

Strategic Defense Initiative Organization

Research sponsored by the Strategic Defense Initiative serves as a catalyst for spinoffs in many scientific and technical fields. Spinoffs have been developed successfully in areas such as computer technology, materials science, optics, medicine, sensor technology, energy and semiconductor research and development.

Acting under the direction of Congress and the President, SDIO established its Office of Technology Applications in 1986 to implement a program that makes SDI technology available to other Federal agencies, qualified U.S. corporations, small businesses, entrepreneurs, universities, and state and local governments. These technologies are being licensed for use in products and R&D efforts. For additional information, call (202) 693-1556.

SDIO also developed a Technology Applications Information System that uses voluntary scientific and technical specialists from universities, national laboratories, private research institutes, corporations and professional associations throughout the country to help identify potential spinoffs of SDI technology. For additional information, call (202) 693-1563.

Other Space Activities

DOD's primary activity in space involves its military communications satellite capabilities, which are provided by several satellite systems, each tailored to a specific set of requirements. These systems include the Fleet Satellite Communications System (FLTSATCOM), Air Force Satellite Communications (AFTSATCOM), Defense Satellite Communications System (DSCS), Milstar Satellites and Satellite Laser Communications (SLC) System.

DOD also has programs in navigation and geodesy, notably the Global Positioning System (GPS); meteorology and oceanography; and surveillance and warning systems.

Department of Energy

The Department of Energy (DOE) is responsible for the oversight of several major multiprogram and single program research laboratories. These labs, commonly known as the National Laboratories, engage in ongoing research work for DOE and also represent valuable, often unique, resources for university and commercial developers in many important research fields. It is the policy of the DOE to make its laboratories and facilities available to qualified scientists who can make the best use of these capabilities.

The activities of the National Labs and the cooperation between foreign governments and their industries provide additional examples of government-industry cooperation. A number of the U.S. Labs that conduct research in many of the high-technology areas are owned by the government and operated by the private sector. Beginning in the 1980s, the labs have been placing more emphasis on the importance of technology transfer to the private sector. Some labs, such as Oak Ridge in Tennessee, have technology transfer departments which assist in the commercialization of technologies developed at the lab by offering businesses licensing agreements. In some instances, businesses with successful products must give some of their profits to the laboratories.

Department of Energy (continued)

Department of Energy – National Labs

Ames Laboratory
Iowa State University
Ames, Iowa 50011
(515) 294-2770

Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439
(312) 972-5555

Bates Linear Accelerator Facility
Massachusetts Institute of Technology
P.O. Box 95
Middleton, MA 01949

Brookhaven National Laboratory
Upton, Long Island, NY 11973
(516) 282-3000

Component Development Integration Facility
P.O. Box 3767
Butte, MT 59702
(406) 494-7313

Energy Technology Engineering Center
P.O. Box 1449
Canoga Park, CA 93104
(213) 700-5326

Fermi National Accelerator Laboratory
P.O. Box 500
Batavia, IL 60510
(312) 840-3000

Geothermal Test Facility
c/o WESTEC Services, Inc.
P.O. Box 791
Holtville, CA 92250

Grand Junction Facility
Grand Junction Area Office
P.O. Box 2567
Grand Junction, CO 81502
(303) 242-8621

Idaho National Engineering Laboratory
Idaho Falls, ID 83401
(208) 526-0111

Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720
(415) 486-4000

Los Alamos National Laboratory
University of California
P.O. Box 1663
Los Alamos, NM 87545
(505) 667-5061

Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, TN 37830
(615) 576-5454

Pacific Northwest Laboratory
P.O. Box 999
Richland, WA 99352
(509) 375-2559

Sandia National Laboratories
Albuquerque, NM 87185
(505) 844-5678

Sandia National Laboratories
P.O.Box 969
Livermore, CA 94550
(415) 422-7011

Savannah River Laboratory
Aiken, SC 29801
(803) 725-2277

Savannah River Laboratory
Drawer E
Aiken, SC 29801
(803) 725-2472

Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401
(303) 231-7115

Stanford Linear Accelerator Center
Stanford University
P.O. Box 4349
Stanford, CA 94305
(415) 854-3300

Other Organizations

The government's role in nurturing an environment that will encourage U.S. private sector participation and investment in space includes creating opportunities through the development of new technology, infrastructure and favorable policies while concurrently minimizing bureaucratic obstacles; informing the public of opportunities, technology and policies; and stimulating private-sector investments by reducing business capital requirements and reducing both real and perceived risks.

In addition to the government agencies previously discussed in this section, the following organizations and entries also are involved in the commercial development of space.

COSMIC

COSMIC is the NASA/Computer Software Management and Information Center, a central office established to distribute software developed with NASA funding. Since its beginning in 1966, COSMIC has been operated by The University of Georgia.

COSMIC's role as part of the NASA Technology Transfer Network is to ensure that industry, other government agencies and academic institutions have access to the advanced computer software technology produced for NASA projects. COSMIC publishes an annual Software Catalog containing over 1100 computer programs available for use within the United States. An international catalog is published also. In addition to the annual catalogs, brochures and collections of program abstracts are available, covering specific subject areas:

- Artificial intelligence and expert systems
- CAD/CAM
- Composites
- Computational fluid dynamics
- Control systems and robotics
- DEC VAX Utilities
- Finite element analysis
- Heat transfer and fluid flow
- Image processing
- IBM mainframe utilities
- Microcomputers
- Optics and lens design
- Project management
- Reliability
- Satellite/communication
- Scientific visualization
- Trajectories and orbital mechanics
- Turbine engineering
- UNIX utilities

Program source code is provided to permit modification or enhancement for particular applications. The program documentation is sold separately to allow for the review of program capabilities in detail before an expensive purchase decision is made. Ongoing development of NASA software provides new programs for the COSMIC inventory throughout the year. The COSMIC Customer Support Staff offers information about recent additions or programs in progress.

Contact: Customer Support, COSMIC
University of Georgia
382 East Broad St.
Athens, GA 30602
(404) 542-3265, Fax (404) 542-4807

Federal Communications Commission

Satellite communications has been the most profitable and thriving space business for more than 25 years. The Federal Communications Commission (FCC) is responsible for assigning appropriate frequencies and orbital slots for satellite communications from the international agreements reached under the auspices of the International Telecommunication Union, and for issuing individual licenses for the construction and operation of each satellite. FCC review and approval has been the only significant regulatory restraint on the burgeoning space communications business.

Every space endeavor requires the use of radio frequencies at some point. For example, FCC approval is required for licensing a radio operator to control an object or payload in space and for assigning the necessary radio frequencies for a particular mission, such as data transmission to Earth for a remote sensing system.

NASA/Space Engineering Research Center for Very Large Scale Integration System (VLSI) Design

The objective of this center is to design high performance VLSI processors for space applications. Processors already designed or in the final design cycle include:

- High performance Reed Solomon CCSDS (Consultative Committee for Space Data Systems) chip(s) that perform in excess of 1 billion operations per second at data rates of 80 Mbits/second
- Space Qualified Reed Solomon encoder chip for CCSDS standard that operates at 200 Mbits/second
- Image compression/decompression chip set that operates at 10 Msamples/second
- Automatic centroid calculator for wide-angle field of view camera

The Center features a team of professional full-custom VSLI engineers capable of military and commercial quality design.

Contact: Gary K. Maki, Director
NASA/Space Engineering Research Center for VLSI Systems Design
Electrical Engineering Department
University of Idaho
Moscow, ID 83843
(208) 885-6500

National Space Council

The National Space Council, chaired by the Vice President, was created by the Congress to help the President in developing a National Space Policy and strategy and to monitor its implementation. One of the key goals of the Space Policy includes encouraging a self-sustaining, market-driven commercial space sector which will generate significant economic benefits for the nation, as well as supporting the government space sectors with an expanding range of goods and services.

The National Space Council coordinates several major interagency reviews to ensure that the National Space Policy is being implemented as effectively as possible. One of these reviews included a major assessment of commercial space policy in 1990. This effort reflected the President's commitment to exploring how the private and public sectors can best work together so that our space program uses its national assets in the most cost-effective way possible.

Contact: Courtney A. Stadd
Senior Director, Commercial Space
National Space Council
The White House
Washington, DC 20500
(202) 395-6175

State Organizations

A number of state governments are organizing to develop space business programs, facilities and industrial capabilities. Examples of interest include the following activities:

- Florida and Hawaii have active space development programs for establishing commercial spaceports and supporting related industry developments.
- Virginia's Center for Innovative Technology attracts and develops high-technology industry and incubator programs, among them, several space-related initiatives, and an effort to develop a commercial launch site at Wallops Island also is underway.
- West Virginia is engaged in attracting space industry by establishing research parks that offer special incentives to space industry.
- Texas has an active program to encourage private-sector research in fields such as space medical technology.
- Utah, Illinois, Colorado, California, Alabama, Ohio, New Mexico, Louisiana and Mississippi also are initiating commercial space activities at a state government level.

State Space Program Contacts

Alabama
Harry Atkins, Special Asst. for Aerospace Development
Department of Economic and Community Affairs
3465 Norman Bridge Road
P.O. Box 25034
Montgomery, AL 36125
(205) 284-8952

California
Thomas Walters
California Department of Commerce
Office of Innovative Technology
1121 L Street, Suite 600
Sacramento, CA 95814
(916) 322-1394

Colorado
John Darrah
Commission of Space Science and Industry
Air Force Space Command/CN
Peterson Air Force Base, CO 80914
(719) 554-3497

Florida
Edward O'Connor, Executive Director
Spaceport Florida Authority
150 Cocoa Isles Boulevard, Suite 401
Cocoa Beach, FL 32931
(407) 868-6983, Fax (407) 868-6987

Hawaii
George Mead, Executive Director
Office of Space Industry
Hawaii Space Development Authority
P.O. Box 2359
Honolulu, HI 96804
(808) 548-3451, Fax (808) 548-8156

New Mexico
Burton H. Lee, Consultant
Commercial Space Programs
Physical Science Laboratory
New Mexico State University
P.O. Box 30002
Las Cruces, NM 88003
(505) 522-9323, Fax (505) 522-9389

Ohio
Michael Salkind
Ohio Aerospace Institute
2001 Aerospace Parkway
Brook Park, OH 44142
(216) 891-2100, Fax (216) 891-2140

Texas
Oran W. Nicks
Texas Space Commission
223 WERC
Texas A&M University
College Station, TX 77843-3118
(409) 845-5293, Fax (409) 847-8857

Utah
Lt. Governor Val Oveson
State Capitol
Salt Lake City, UT 84114
(801) 538-1520

Virginia
Stephen L. Morgan, Director
Space Industry Development
Center for Innovative Technology
CIT Tower, Suite 600
2214 Rock Hill Road
Herndon, VA 22070
(703) 689-3024, Fax (703) 689-3041

West Virginia
Susan Shemenko
State Capitol Complex
Building 5, Room A-109
Charlestown, VA 25305
(304) 348-0444

Aerospace States Association (ASA)

The Aerospace States Association (ASA) is an organization that brings together representatives from states with interests in furthering their participation in the commercial space community. One of its central purposes is to ensure that states' interests are represented in the federal policy development process. The organization is being coordinated by Virginia's Center for Innovative Technology.

Contact: Stephen Morgan
Center for Innovative Technology
CIT Building, Suite 600
2214 Rock Hill Road
Herndon, VA 22070
(703) 689-3024, Fax (703) 689-3041

Section Eight: Information Sources

In addition to commercial services and products, agencies of the government and academic organizations, the commercial developer is referred to publications, directories and membership groups that also may serve as support sources. This section offers a sampling of these sources.

Chapter 24: Publications

The commercial space developer may keep advised of the latest information in the field by reviewing any of the following suggested publications on a daily, weekly, monthly or quarterly basis. All of these documents may be obtained on a subscription basis or may be found in libraries.

This chapter also includes a brief listing of recent reports and studies pertinent to issues concerning remote sensing, space commerce and ventures, space transportation systems, spacecraft servicing, legal policies and intellectual property.

Ad Astra (monthly)
Palmer Publications, Inc.
P.O. Box 296, 318 N. Main Street
Amherst, WI 54406
(715) 824-3214

Aerospace America (monthly)
American Institute of Aeronautics and Astronautics
370 L'Enfant Promenade SW
Washington, DC 20024
(202) 646-7471

Aerospace Daily (daily)
World Aviation
1156 15th Street NW
Washington, DC 20005
(202) 822-4600

Aviation Week and Space Technology (weekly)
McGraw-Hill Publications
1221 Avenue of the Americas
New York, NY 10020
(212) 512-2000

Commercial Space Developments (quarterly)
NASA/Office of Commercial Programs
NASA Headquarters/Code CC
Washington, DC 20546
(703) 557-4640

SPACE (bimonthly)
The Shephard Press Ltd.
111 High Street
Burnham, Bucks SL1 7JZ, England

Space Business News (biweekly)
Pasha Publications, Inc.
1401 N. Wilson Blvd., Suite 900
Arlington, VA 22209
(703) 528-1244

Space Calendar, (weekly)
75-5751 Kuakini Highway, Suite 209
Kailua-Kona, HI 96740
(808) 326-2014

Space Commerce (quarterly)
Harwood Academic Publishers GmbH
c/o STBS Ltd., P.O. Box 197
London, WC2E 9PX, England

Space Markets (bimonthly)
Interavia SA
20 route de Pre-Bois
P.O. Box 636
CH-1215, Geneva 15, Switzerland

Space News (weekly)
6883 Commercial Drive
Springfield, VA 22159
(703) 750-2000

Space Policy (quarterly)
Butterworth Scientific Ltd.
P.O. Box 63
Westbury House, Bury Street
Guildford, Surrey GU2 5BH, England

Space Station News (weekly)
1850 M Street NW
Washington, DC 20036
(202) 429-1888

The following reports on commercial applications of remote sensing are available from the NASA/Stennis Space Center. Call (601) 688-2042.

- *Commercial Earth Observation Payload Integration Into the Shuttle Orbiter Middeck*, LESC-27840
- *A Description of the Regulatory Process to Launch a Commercial Earth Observation Satellite on a Commercial Launch Vehicle*, LESC-27841
  - Volume I: Department of Transportation and National Launch Range Regulations
  - Volume II: Department of Commerce Regulations
- *Lightsat Technology Status Report*, LESC-28032
- *Planning For Large Format Camera Reflight Options*, LESC-27563
- *Payload Workstation Requirements Second Survey Results and Analysis*

The following reports on commercial space activities were published by the U.S. Office of Space Commerce, Department of Commerce.
Call (202) 377-8125.

- *COMMERCIAL SPACE VENTURES: A Financial Perspective* (1990)
- *SPACE COMMERCE: An Industry Assessment* (1988)

The following reports on space transportation systems and spacecraft alternatives are available from the U.S. Office of Technology Assessment. Call U.S. Government Printing Office, (202) 783-3238.

- *AFFORDABLE SPACECRAFT: Design & Launch Alternatives - Background Paper* (1990), GPO Stock #052-003-01174-3
- *ACCESS TO SPACE: The Future of U.S. Space Transportation Systems* (1990), GPO Stock #052-003-01177-8
- *ROUND TRIP TO ORBIT: Human Spaceflight Alternatives* (1989), GPO Stock #052-003-01155-7
- *REDUCING LAUNCH OPERATIONS COSTS: New Technologies and Practices* (1988), GPO Stock #052-003-01118-2
- *LAUNCH OPTIONS FOR THE FUTURE: A Buyer's Guide* (1988), GPO Stock #052-003-01117-4

The following reports were published by the National Legal Center. Call (202) 296-1683.

- *AMERICA ENTERPRISE, THE LAW, AND THE COMMERCIAL USE OF SPACE* (three volumes)
  - Vol. 1, An Analysis of Treaties, Legislation, Regulation and the Political Scenario (1985)
  - Vol. 2, Remote Sensing and Telecommunications: How Free? How Regulated? (1986)
  - Vol. 3, Jurisdiction, Tort Law, Intellectual Property, Communications, Taxation, Patents and Insurance (1987)

- *PROTECTING SCIENTIFIC IDEAS AND INVENTIONS* (1988), by R.D. Flotz and T.A. Penn. CRC Press, 2000 Corporation Blvd., Boca Raton, FL 33431

- *DISCOVER THE VALUE* (1990), a documentary about the Centers for the Commercial Development of Space, produced on videotape by NASA/Kennedy Space Center. Call (407) 867-3374.

This publication features information, guidelines and recommendations for designing spacecraft payloads and equipment for manual servicing (extravehicular activity (EVA) astronauts) and telerobotic servicing (remote manipulators). Contact Janice Nyman, ERIM, Space Automation and Robotics Center (SpARC), P.O. Box 8618, Ann Arbor, MI 48107-8618, (313) 994-1200, ext. 2469.

- *DESIGN FOR ON-ORBIT SPACECRAFT SERVICING, DFOSS Handbook* (1990)

This report is available from the Office of Commercial Space Transportation, Licensing Programs Division. Call (202) 366-5770.

- *HAZARD ANALYSIS OF COMMERCIAL SPACE TRANSPORTATION* (1988) (three volumes)
  - Vol. 1, Operations
  - Vol. 2, Hazards
  - Vol. 3, Risk Analysis

This report is available from the Center for Innovative Technology (CIT). Call (703) 689-3024.

- *AN ASSESSMENT OF POTENTIAL MARKETS FOR SMALL SATELLITES* (1989)

Chapter 25: Directories and Catalogues

Several organizations and businesses in the United States and Europe regularly issue catalogues and directories that may be used as references for a broad range of information that may be of interest to commercial space developers. What follows is a partial listing of these resource materials, which may be purchased or received upon request.

Accessing Space: A Catalogue of Process, Equipment and Resources for Commercial Users (biannual)
NASA/Office of Commercial Programs
NASA Headquarters/Code CC
Washington DC 20546
(703) 557-4626

European Space Directory (annual)
Sevig Press Publishing Company
331 W. Wilson Ave., Suite 101
Glendale, CA 91203
(818) 500-1930

Interavia Space Directory (annual)
Jane's Information Group
Department DSM
1340 Braddock Place, Suite 300
Alexandria, VA 22314

The International Space Directory (annual)
The Shephard Press Ltd.
111 High Street
Burnham, Buckinghamshire SL1 7JZ, England

The PROSPACE Catalog (4 volumes)
Prospace
2, place Maurice Quentin
75039 Paris cedex 01, France
– Vol. 1, Prospace Members
– Vol. 2, Onboard Equipment
– Vol. 3, Ground Equipment
– Vol. 4, Services

The Soviet Year in Space (annual)
Teledyne Brown Engineering
Colorado Springs Office
1250 Academy Park Loop, Suite 240
Colorado Springs, CO 80910
(303) 574-7270

Space Technology International (annual)
Cornhill Publications Ltd.
4-7 Nottingham Court
Short's Gardens
London WC2H 9AY, England

World Space Industry Survey (annual)
Euroconsult
71, bd Richard-Lenoir
F-75011 Paris, France

Chapter 26: Organizations

The number of active professional and advocacy membership organizations continues to grow and to expand in focus as space development activity moves through disciplines, regions and industries. This chapter includes a partial listing of such organizations and programs.

Aerospace Industries Association (AIA)
1250 Eye Street NW
Washington, DC 20005
(202) 371-8400

Aerospace States Association
c/o Center for Innovative Technology
CIT Building, Suite 600
2214 Rock Hill Road
Herndon, VA 22070
(703) 689-3024

American Astronautical Society (AAS)
6352 Rolling Mill Place, Suite 102
Springfield, VA 22152
(703) 886-0020

American Institute of Aeronautics and Astronautics
370 L'Enfant Promenade SW
Washington DC 20024
(202) 646-7400

Association of Space Explorers, ASE-USA
3263 Sacramento Street
San Francisco, CA
(415) 931-0585

California Space Grant Consortium
Code B-017
University of California/San Diego
La Jolla, CA 92093
(619) 534-7441

California Space Institute
CalSpace A-021
University of California/San Diego
La Jolla, CA 92093
(619) 534-2908

Center for Space and Geosciences Policy
Campus Box 361
University of Colorado/Boulder
Boulder, CO 80309
(303) 492-1171

Center for Innovative Technology (CIT)
CIT Tower, Suite 600
2214 Rock Hill Road
Herndon, VA 22070
(703) 689-3000

Georgia Tech Research Institute
Georgia Institute of Technology
Atlanta, GA 30332
(404) 894-3530

The Geosat Committee, Inc.
601 Elm Street, Room 438C
Norman, OK 73019
(405) 325-3329

Institute for Security and Cooperation in Outer Space
1336A Corcoran Street NW
Washington, DC 20009
(202) 462-8886

International Hypersonic Research Institute
University of Central Florida
Political Science Dept.
P.O. Box 25000
Orlando, FL 32816
(407)366-1764

International Space University
955 Massachusetts Avenue
Cambridge, MA 02139,
(617) 354-1987

International Space Year Association (US-ISY)
600 Maryland Ave. SW
Washington, DC 20024
(202) 863-1734

Lunar and Planetary Institute
3303 NASA Road One
Houston, TX 77098
(713) 486-2196

National Space Club
655 15th Street NW
Washington, DC 20005
(202) 639-4210

National Space Society (NSS)
922 Pennsylvania Ave. SE
Washington, DC 20024
(202) 543-1900

The Planetary Society
65 N. Catalina Ave.
Pasadena, CA 91106
(818) 793-5100

The Space Foundation
P.O. Box 27017
Washington, DC 20038
(202) 347-2414

Space Studies Institute (SSI)
P.O. Box 82
Princeton, NJ 08540
(609) 921-0377

Spaceweek National Headquarters
P.O. Box 58172
Houston TX 77258
(713) 480-0007

Universities Space Research Association (USRA)
600 Maryland Ave. SW
Washington, DC 20024
(202) 547-2506

U.S. Space Foundation
P.O. Box 1838
Colorado Springs, CO 80916
(719) 550-1000

Woman in Aerospace (WIA)
6352 Rolling Mill Place, Suite 102
Springfield, VA 22152
(703) 886-0020

World Space Foundation (WSF)
P.O. Box Y
S. Pasadena, CA 91030
(818) 357-2878

Appendix

Included in this section is a cross-referenced index to all entries in this catalogue, a listing of commonly used acronyms and a page for submissions to the next edition of **Accessing Space** (planned for 1992). In addition to updated and new information, the editors and publishers of this document appreciate and welcome all comments and suggestions.

Acronyms

As with many populations of profession and discipline, the space community is renowned for its capacity to create acronyms at every opportunity. The following listing was compiled explicitly with the commercial space developer in mind, in an effort to translate some of the "alphabet soup" into meaningful language.

ac	Alternating current
A&I	Assembly and Installation
ACS	Attitude Control System
AFD	Aft Flight Deck
ALS	Advanced Launch System
AO	Announcement of Opportunity
APC	Autonomous Payload Controller
ARC	Ames Research Center
AR/IRR	Acceptance Review/Integration Readiness Review
ARS	Air Revitalization System
CCAFS	Cape Canaveral Air Force Station
CCAP	Commercial Development Payload
CCDS	Center for the Commercial Development of Space
CCTV	Closed Circuit Television
CDMS	Command and Data Management Subsystem
CDR	Critical Design Review
CDSF	Commercially Developed Space Facility
CELSS	Closed Environmental Life Support System
CERV	Crew Emergency Return Vehicle
CIFS	Critical Initial Flaw Size
cm	Centimeter
CMC	Center for Macromolecular Crystallography
CMD	Command
COMET	COMmercial Experiment Transporter Program
cont	Continuous
CPAC	Commercial Programs Advisory Committee
CRT	Cathode Ray Tube
cu^3	Cubic meters
DARPA	Defense Advanced Research Project Agency
dc	Direct current
DDL	Dedicated Discipline Laboratory
DDS	Data Display System
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DOMSAT	Domestic Satellite
DR	Double Rack
EAC	Experiment Apparatus Container
EC	Experiment Computer
ECAS	Experiment Computer Application Software
ECE	Experiment Checkout Equipment
ECIO	Experiment Computer I/O
ECOS	Experiment Computer Operating System
ECS	Environment Control System
EGF	Electrical Grapple Fixture
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMP	Enhanced MDM Pallet
EOCAP	Earth Observations Commercialization Applications Program
EOS	Electrophoresis Operations in Space
EPSP	Experiment Power Switching Panel
ERD	Experiment Requirements Document

ESMC	Eastern Space and Missile Center
ETR	Experiment Tape Recorder
EVA	Extravehicular Activity
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEO	Flight Experiment Opportunity
FDD	Flight Definition Document
FM	Frequency Modulation
FMDM	Flexible Multiplexer/Demultiplexer
FO	Functional Objective
ft	Feet
ft^2	Square feet
ft^3	Cubic feet
fwd	Forward
g	Acceleration due to gravity
GAS	Get-Away-Special
GBA	GAS Bride Assembly
GBS	GAS Bridge System
Gbyte	Gigabyte
GIRD	Ground Integration Requirements Document
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation and Control
GPC	General Purpose Computer
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
H	Height
HDRR	High Data Rate Recorder
HH-G	Hitchhiker-G
HH-M	Hitchhiker-M
HRM	High Rate Multiplexer
IAC	Industrial Applications Center
ICD	Interface Control Document
IECM	Induced Environment Contamination Monitor
IGI	Industrial Guest Investigator
IIA	Instrument Interface Agreement
IMU	Inertial Measurement Unit
In	Inch
I/O	Input/Output
IPL	Integrated Payload
IPMP	Investigations into Polymer Membrane Processing
IPOTP	Integrated Payload Operations Training Plan
IPRD	Integrated Payload Requirements Document
IPS	Instrument Pointing Subsystem
ISF	Industrial Space Facility
IVA	Intravehicular Activity
IWG	Investigator Working Group
JEA	Joint Endeavor Agreement
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
kbps	Kilobits per second
kbytes	Kilobytes
kg	Kilogram
kHz	Kilohertz
KSC	Kennedy Space Center
KuSP	Ku-Band Signal Processor
kW	KiloWatt
L	Length
LaRC	Langley Research Center
lbs	Pounds
LDEF	Long Duration Exposure Facility
LeRC	Lewis Research Center
liq.	Liquid
LOX	Liquid oxygen
LM	Long Module
LSA	Launch Services Agreement
LTA	Linear Tri-Axial Accelerometer
m	Meter
m^2	Square meters
MAR	Middeck Accommodations Rack
max	Maximum
Mbps	Megabits per second
Mbytes	Megabytes
MC	Modular Container
MCC	Mission Control Center

MCDS	Multifunctional CRT Display System
MD	Middeck
MDL	Middeck Locker
MDM	Multiplexer/Demultiplexer
MET	Mission Elapsed Time
MFCC	Missile Flight Control Center
MHz	MegaHertz
min	Minimum
MIUL	Materials Identification and Usage List
mm	Millimeter
MMSL	Microgravity Materials Science Laboratory
MMU	Manned Maneuvering Unit (or Mass Memory Unit)
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPE	Mission Peculiar Equipment
MPESS	Multi-Purpose Experiment Support Structure
MSFC	Marshall Space Flight Center
MSL	Materials Science Laboratory
MTU	Master Timing Unit
MUA	Materials Usage Agreement
N/A	Non Applicable
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications Network
NASP	National Aerospace Place
NRT	Near real time
NSP	Network Signal Processor
O&C	Operations and Checkout
O&IA	Operations and Integration Agreement
OCP	Office of Commercial Programs (NASA)
OCST	Office of Commercial Space Transportation
OFT	Orbital Flight Test
OPF	Orbital Processing Facility
OR	Operational Recorder
OSTP	Office of Science and Advanced Technology
OTA	Office of Technology Assessment
PATH	Postflight Attitude and Trajectory History
PCB	Power Control Box
PCG	Protein Crystal Growth
PCMMU	Pulse Code Modulation Master Unit
PDI	Payload Data Interleaver
PDP	Plasma Diagnostic Package
PDR	Preliminary Design Review
PED	Payload Element Developer
PI	Payload Interrogator (or Principal Investigator)
PIP	Payload Integration Plan
PMM	Payload Mission Manager
POCC	Payload Operations Control Center
POD	Payload Operation Director
PR	Payload Recorder
PRR	Preliminary Requirements Review
PSP	Payload Signal Processor
PTO	(U.S.) Patent and Trade Office
RAU	Remote Acquisition Unit
R&D	Research and Development
REM	Release and Engage Mechanism
RF	Radio frequency
RFP	Request for Proposal
RMS	Remote Manipulator System
SAL	Scientific Airlock
SANC	Spacelab Ancillary Data Tape
SC	Subsystem Computer
SCU	Systems Control Unit
SDIO	Strategic Defense Initiative Organization
SDMU	Serial Data Management Unit
sec	Second
SEDT	Spacelab Experiment Data Tape
SFMDM	Smart FMDM
SFSS	Spartan Flight Support Structure
SIDT	Spacelab I/O Data Tape
SII	Space Industries Incorporated
SL	Spacelab
SLDPF	Spacelab Data Processing Facility

SLLM	Spacelab Long Module
SLS	Space Life Sciences
SLSM	Spacelab Short Module
SM	Short Module
SMCH	Standard Mixed Cargo Harness
SMIDEX	Spacelab Middeck Experiment
SPAH	Spacelab Payload Accommodations Handbook
SR	Single Rack
SRM	Solid Rocket Motor
SS	Space Station
SSC	Stennis Space Center
SSDA	Space Systems Development Agreement
SSP	Standard Switch Panel
STEP	Space Technology Experiments Platform
STS	Space Transportation System
SWAA	Spacelab Window Adapter Assembly
TBD	To Be Determined
TDRS	Tracking and Data Relay Satellite
TEA	Technical Exchange Agreement
TLM	Telemetry
USL	United States Laboratory
V	Volt
VAA	Viewport Adapter Assembly
VAFB	Vandenberg Air Force Base
VPF	Vertical Processing Facility
W	Width (or Watt)
WFF	Wallops Flight Facility
w/o	With out
WSF	Wake Shield Facility
WSMC	Western Space and Missile Center
WSTF	White Sands Test Facility
Y/N	Yes/No

Accessing Space – Submission Instructions

If you believe your company or organization should be included in this catalogue, we are interested in considering your entry for the next edition. Please note that NASA reserves editorial and acceptance rights on all submissions for this document and is not accountable for the return of any materials submitted. To assure consideration for inclusion in the next edition, please include your name, title, address and telephone/fax numbers on business letterhead, along with a brief description of the entry you propose to include to the following:

Accessing Space Catalogue
Office of Commercial Programs
NASA Headquarters Code CCL
Washington, DC 20546

We also are interested to know if your current entry has changed sufficiently to warrant a significant revision. Plans call for the next edition of **Accessing Space** to be issued in late 1992. However, those plans are subject to change (earlier or later) depending upon a number of factors, including the number of possible new entries and revisions. When activities begin on the next edition, or its equivalent, you will be contacted regarding how and when to provide your submission. For your information, instructions for submissions for this edition of **Accessing Space** are as follows:

- Name of product, service or resource (with acronym, if appropriate)
- A brief description (500 words or less) with enough information to enable readers to know what it is, does and who might use it.
- List important characteristics; such as dimensions, weight, carrier, other requirements and/or limitations.
- Is your product, service, etc. currently available, tested or under development?
- Please provide a contact, someone familiar with this product who will be able to answer questions or assist others with it. Make sure to include the contact's name, title, the company name, address, city, state, zip code, telephone number and fax number as available.
- Please suggest the category most appropriate for your entry. (Use the Table of Contents as a guide.)
- Provide, as appropriate, a camera-ready line drawing (photographs or tone drawings are not acceptable).

Index

Q

R

S

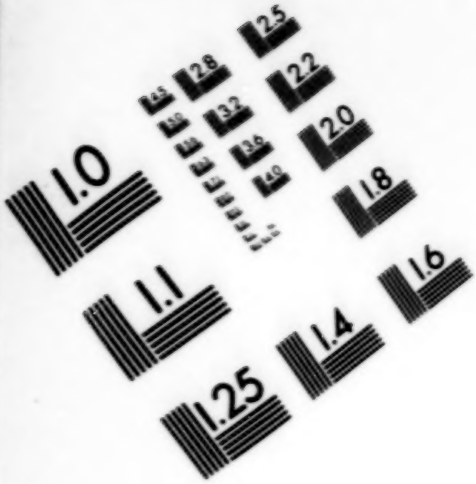
*U.S. GOVERNMENT PRINTING OFFICE: 1991-295-591

END

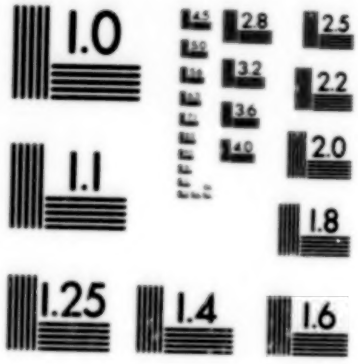
DATE

FILMED

FEB 8 1992



Association for Information and Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202



MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.